Big Telescope Sweepstakes!

How to Capture a Comet on Film

ASTRONOMY®

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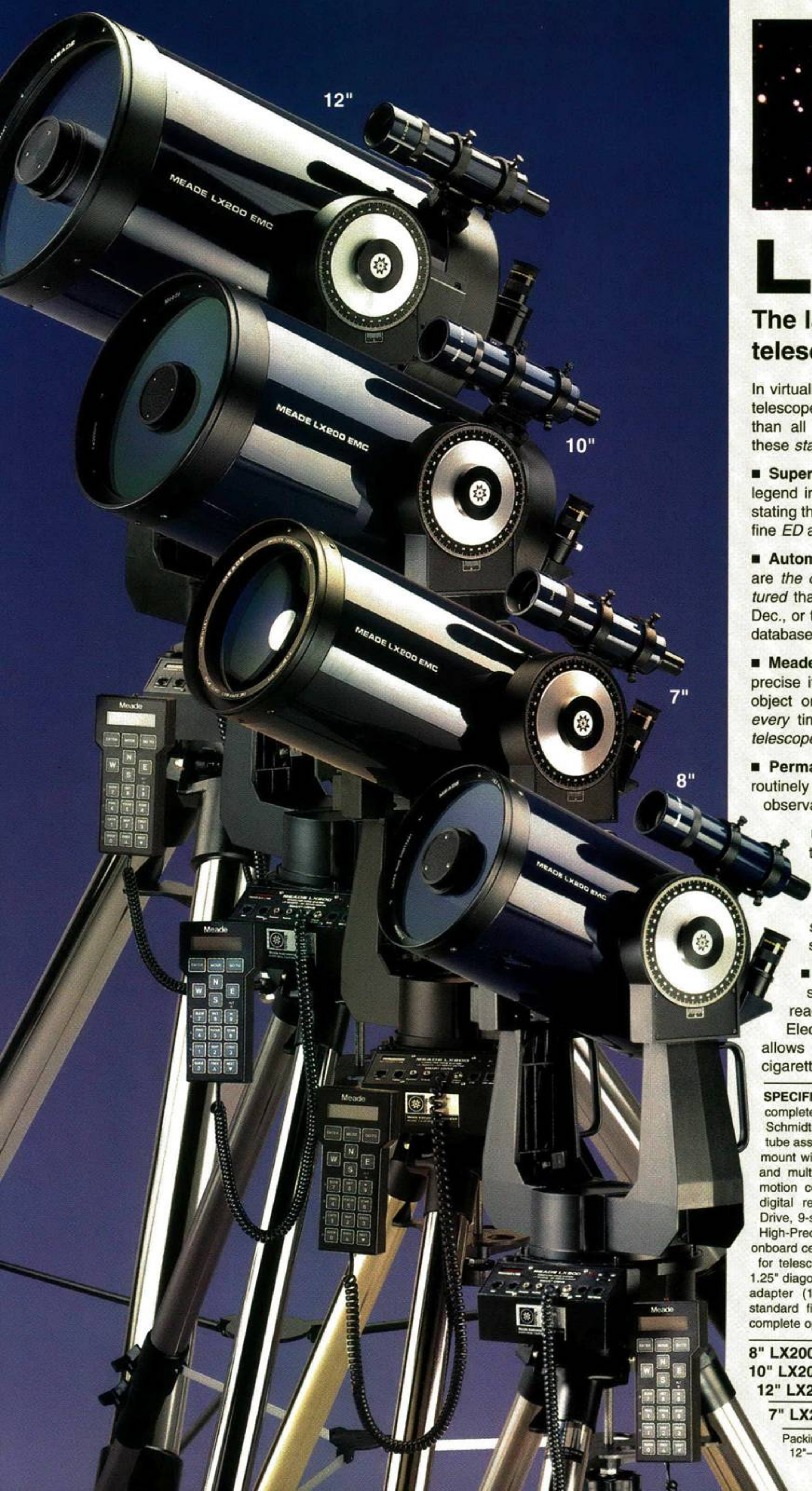
New Planet Found Orbiting a Sun-like Star

Galileo at Jupiter

Easy Double Stars for Small Telescopes

Build a Portable Power Box



LX200

The largest-selling serious telescopes in the world.

In virtually every country in the world where serious telescopes are sold, more Meade LX200's are sold than all competing models ***combined***. Consider these *standard-equipment* specifications:

- **Superb Optics:** LX200 imaging capabilities are a legend in the industry; we regularly receive reports stating that optical performance approaches that of a fine *ED* apochromatic lens.
- **Automatic GO TO Capability:** Meade LX200's are *the only commercial telescopes ever manufactured* that automatically GO TO any input R.A. and Dec., or to any of over 64,350 objects in the onboard database, *to a precision of one arc-minute or better.*
- **Meade LX200 High-Precision Pointing™** is so precise it permits the positioning of *every* selected object on *every* commercially-available CCD chip *every* time, automatically — *a feat that no other telescope priced under $40,000 can accomplish.*
- **Permanently-Programmable Smart Drive™** routinely achieves 5 arc. sec. periodic error, an observatory standard.
- **9-Speed Dual-Axis Electronics:** Electronics that cover every possible contingency of telescope positioning—from 2x photo-guide, to 32x image centering, to 8°/sec. slewing across the sky, as well as 6 other dual-axis drive speeds in between.
- **Field Operation:** No other telescopes of such incredible capabilities transport so readily for field operation. The optional #1812 Electronic DC Adapter (a compact 4 oz. unit) allows for field powering directly from an auto cigarette lighter plug.

SPECIFICATIONS: 7", 8", 10", and 12" LX200's—Each complete telescope includes 8" or 10" (f/6.3 or f/10) or 12" f/10 Schmidt-Cassegrain or 7" f/15 Maksutov-Cassegrain optical tube assembly with EMC super multi-coatings; heavy-duty fork mount with 4" polar ball bearing, dual-axis 5.75" worm gears, and multi-function control panel; manual and electric slow-motion controls on both axes; keypad hand controller with digital readout display, permanently programmable Smart Drive, 9-speed drive controls on both axes (7-speed on 12"), High-Precision Pointing, and GO TO controller; 64,359-object onboard celestial software library; 25 ft. power cord and adapter for telescope operation from 115v.AC; 8 x 50mm viewfinder; 1.25" diagonal prism (7", 8", 10") or 2" diagonal mirror with 1.25" adapter (12"); Series 4000 Super Plössl 26mm eyepiece; standard field tripod (7", 8", 10") or giant field tripod (12"); complete operating instructions.

8" LX200 Schmidt-Cassegrain	**$2495.**
10" LX200 Schmidt-Cassegrain	**2895.**
12" LX200 Schmidt-Cassegrain	**3995.**
7" LX200 Maksutov-Cassegrain	**2995.**

Packing and shipping in the 48 states: 8"—$105; 10"—$145; 12"—$215; 7"—$125.

ADE

LX50

Advanced technology at the most affordable prices ever.

LX50 models shown with optional Field Tripod.

- **Battery-Powered, Completely Cordless Operation!** Meade LX50 models operate for more than 50 hours from four AA-size batteries inserted through the telescope's control panel. Or use the standard-equipment 25 ft. cord to power the telescope directly from any auto cigarette lighter plug.
- **Standard-Equipment Declination Motor and Hand Controller:** Plug the hand controller into the LX50 control panel and you're ready for full dual-axis drive capability at any of 4 photo-guide or microslew speeds: 2x, 8x, 16x, or 32x, plus quartz-controlled sidereal-rate tracking in R.A. Switch speeds instantly using the speed-control button on the hand controller. Dual-axis drive rate is indicated by a red LED.
- **Multi-Function Control Panel:** Includes connectors for CCD autoguiders; for the standard-equipment Declination motor; and for the optional Magellan II Computer-Corrector *(below)*. A North-South switch permits telescope operation anywhere in the world.
- **Super Multi-Coated Optics:** The exact same EMC super multi-coated optical tube assemblies included with Meade LX200 models.
- **Massive LX200-type Fork Mounts:** Meade LX50 mounts are manufactured of the same virgin aluminum castings as Meade LX200 Schmidt-Cassegrains. Massive, rigid mountings that include the Meade LX worm-gear drive system with low periodic error for advanced photographic or CCD imaging applications. *No competing mid-priced equatorial mountings even come close.*

SPECIFICATIONS: 7", 8", and 10" LX50's—Each complete telescope includes 8" or 10" f/10 Schmidt-Cassegrain or 7" f/15 Maksutov-Cassegrain optical tube assembly with EMC super multi-coatings; heavy-duty LX200-type fork mount; 5.75" LX worm gear system in R.A.; multi-function control panel; DC servo Declination motor; manual and electric slow-motion controls on both axes; setting circles on both axes; keypad hand controller; 4-speed drive controls on both axes; battery compartment accepting four (user-supplied) AA-size batteries; 25 ft. power cord for telescope operation from 12v. auto cigarette lighter plug; 6 x 30mm (7" and 8" models) or 8 x 50mm (10") viewfinder; 1.25" diagonal prism; MA25mm multi-coated eyepiece (1.25"); standard equatorial wedge with elevation scale, bubble level, and azimuth control; complete operating instructions.

8" LX50 Schmidt-Cassegrain	**$1195.**
10" LX50 Schmidt-Cassegrain	**1495.**
7" LX50 Maksutov-Cassegrain	**1595.**
Variable-Height Field Tripod	**295.**
7" Maksutov-Cassegrain Tube Ass'y, only	**1195.**

Packing and shipping in the 48 states: 8"—$105; 10"—$145; 7"—$125; 7" Tube Assembly—$65.

Meade Magellan™ II Computer-Corrector for LX50 Telescopes: Plug the Magellan II into the control panel of your LX50 and enjoy an incredible range of advanced capabilities. ■ Fast manual slewing to any object, either from input RA and Dec or from the 12,218-object database. ■ High-resolution 4096-pulse encoders (5.3 arc-minute precision), completely concealed in special LX50 encoder compartments. ■ Quick 2-star alignment. ■ Large 32-character, red-backlighted display. ■ 4-speed (2x, 8x, 16x, 32x sidereal) dual-axis drive corrector/microslewing system.

#2024: Magellan II for LX50's—Includes Magellan II hand controller *(right)*; encoders for both axes; all required mounting hardware. Installs to any LX50 in minutes. **$395.** + $15 packing and shipping in the 48 states.

Send $3.00 to Meade Instruments for the Meade 76-page General Catalog. Prices shown are suggested U.S. mail-order retail prices.

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January 1996
Vol. 24, No. 1

Ronald Royer

78 How to Capture a Comet on Film

COVER 36

Galileo Arrives at Jupiter

Its six-year journey finally over, the Galileo spacecraft prepares to revolutionize our knowledge of the giant planet and its family of satellites. By Paul Weissman and Marcia Segura.

46

Cosmic Billiards

It used to be a normal binary system, but SS Lacertae appears to have lost one of its members when another star collided with it. By Stephen Schiller.

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Second Chance Planets

No one ever expected to find planets in the hostile environs of a pulsar. Now astronomers are trying to figure out how they got there. By Sally Stephens.

58

Sky Almanac

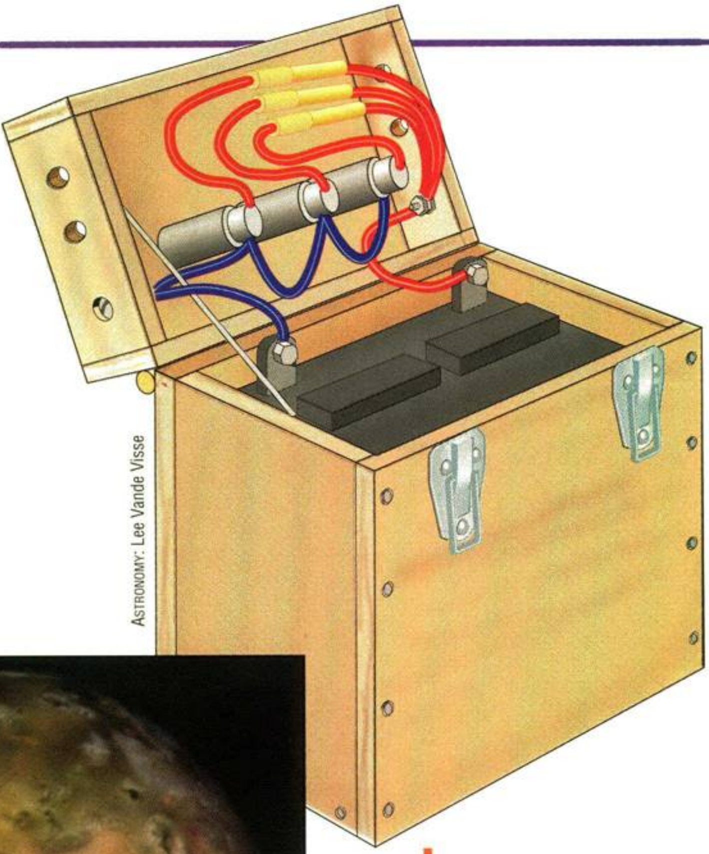
The bright planets stay close to the Sun this month, providing several pretty twilight views as the crescent Moon passes nearby. By Deborah Byrd and Alister Ling.

ON THE COVER

THE LONG WAIT IS OVER, as the Galileo spacecraft goes into orbit around Jupiter and scans the volcano-ravaged surface of its large moon, Io. For more on what Galileo will do during its two-year mission at the Jovian system, see page 36. Illustration by Michael Carroll.

James Collins (Penn State University)

50 **Second Chance Planets**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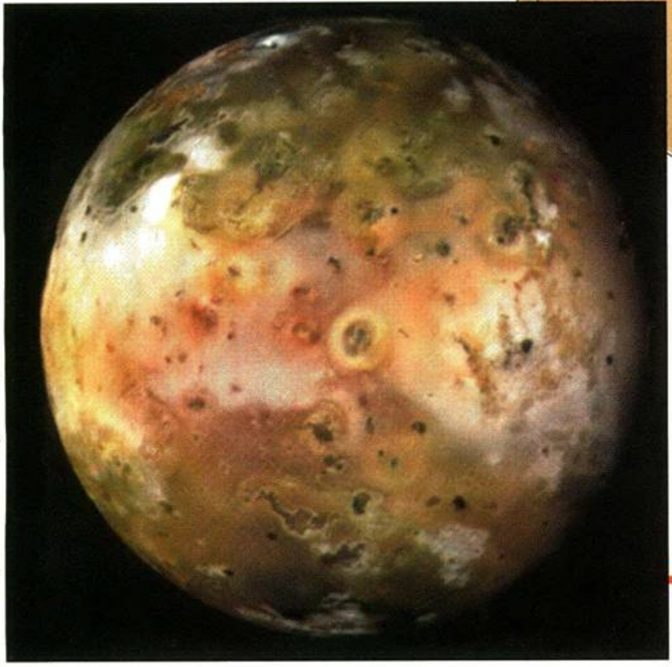
86 **Build a Portable Power Box**


Paul Schenk (Lunar and Planetary Institute)

36 **Galileo at Jupiter**

68 A Trip Through the Wasteland
A small scope can show you surprisingly pretty star clusters and galaxies in the unassuming constellations of Camelopardalis and Lynx. By Lee T. Macdonald.

72 Touring Winter's Best Double Stars
This season's finest doubles offer a wide range of striking colors for viewers with modest telescopes. By Mark T. Stauffer.

78 Catch a Comet on Film
With the bright comet Hale-Bopp set to make an impressive appearance, now's the time to hone your technique for capturing this cosmic interloper. By Rick Dilsizian.

86 Power to Go
If you need electricity to run your telescope out under a dark sky, this quick weekend project is for you. By Joseph Kempter.

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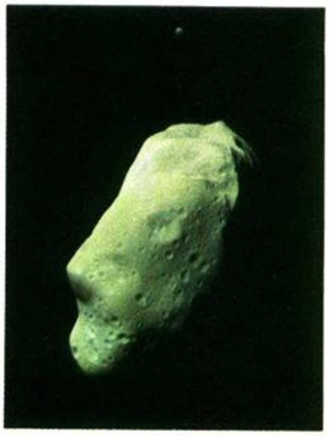
BEHIND THE SCENES

Galileo: Jupiter at Last!

If the past six years since the launch of Galileo have seemed endless, the payoff is finally in sight. The long crawl to Jupiter was forced on Galileo by celestial mechanics and by the errors that led to the explosion of the Space Shuttle Challenger. While the journey has been frustratingly long, the outbound trip has not been wasted — see, for example, the photo below.

But the waiting is now over and the main event is about to begin. The atmospheric probe, which separated from Galileo last July, will plunge into the giant planet's swirling clouds on December 7, then the "mother ship" will fire its engine to go into Jovian orbit. And that's just the start of a 22-month tour of Jupiter's fantastic solar-system-in-miniature.


JPL/NASA

Ida and its moon Dactyl

As we go to press, we've just learned that a last-minute problem with the onboard tape recorder has forced mission scientists to forego the close-up imaging of the moon Io on the day of arrival. However, the rest of the mission, described in the feature that starts on page 36, should proceed as planned and we'll be seeing thousands of images in the next two years.

ASTRONOMY's Galileo coverage is just beginning. As the spacecraft whirls around the planet, visiting one moon and then another, we'll bring you regular stories loaded with images and exciting scientific discoveries. Stay tuned!

On a more mundane note, sharp-eyed readers may spot a change in the typeface we use for stories. Having decided that Optima, our old typeface, had begun to look a little tired, we searched for another that would be easier to read. After much experimentation, we came back to a face (Palatino) that we chose several years ago when we started our sibling magazine, *Earth*. Clear, unobtrusive, and elegant, Palatino is ideal for presenting the most beautiful and exciting subjects in the universe. We hope you like the change.

Sincerely,

Robert Burnham
Editor
rburnham@astronomy.com

LETTERS

SPLAT!

Thanks for "Target Earth" (October 1995). The companion artwork on the cover left me wondering. It seems Manhattan's residents are simply going about their business, judging from the lights showing in many windows. The unwelcome asteroid seems to be the size of an "extinctor." Did the residents leave in a hurry and forget to turn out their lights, or did the tough New Yorkers, true to form, coolly analyze the situation, realize the hopelessness of fleeing, and keep a front row seat? — *Thomas H. Andrews, Duxbury, Massachusetts*

A bright fireball streaked across the sky in the eastern United States and Canada the same day my October issue arrived. Nice choice for the cover story. — *Mitch Goldman, Commack, New York, mitchG17@aol.com*

The illustration in your story is a

(continued on page 16)

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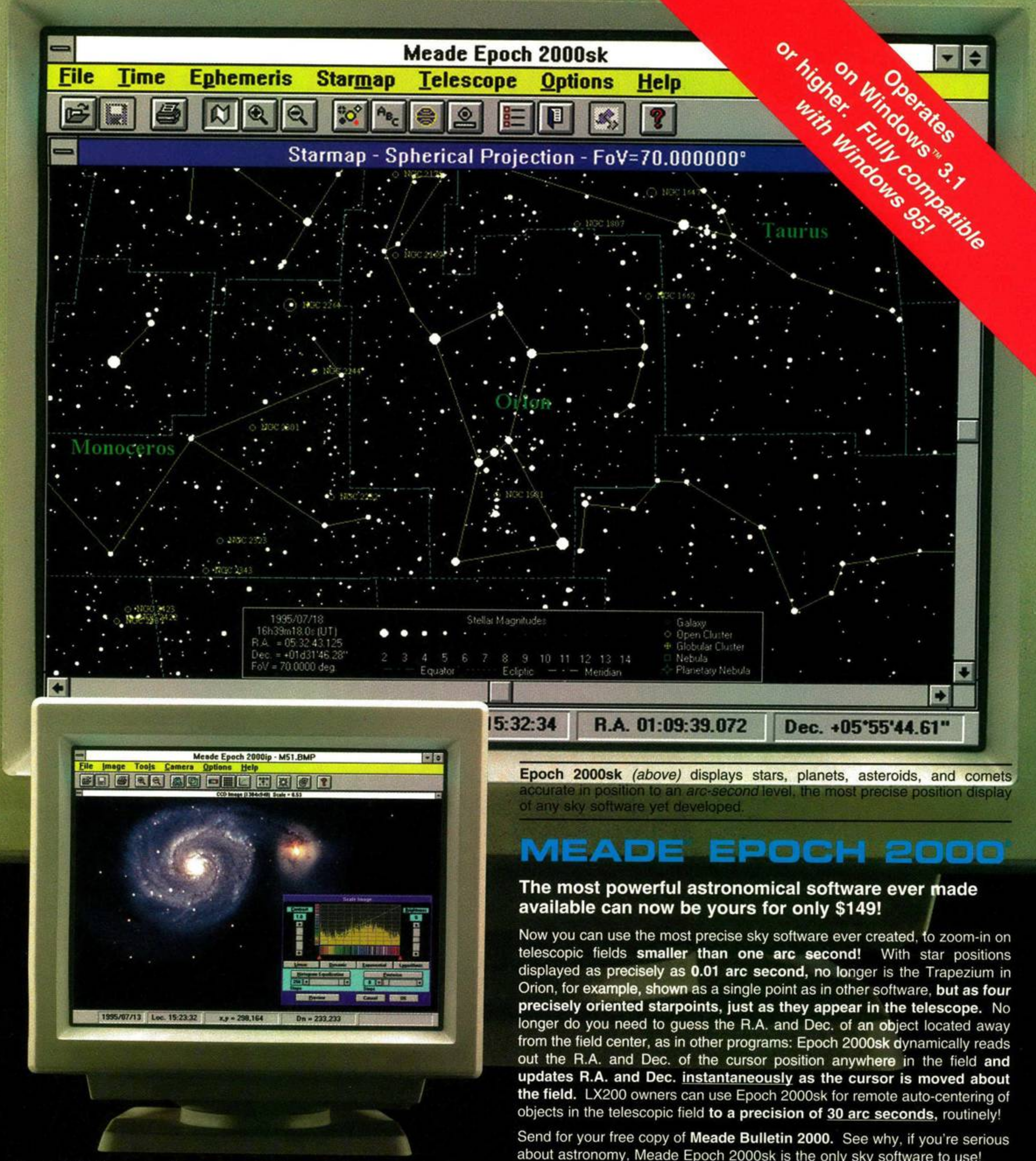
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FoV = 70.0000 deg.

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Dec. +05°55'44.61"

1995/07/13
Loc. 15:23:32
x,y = 298,164
Dn = 233,233

Epoch 2000sk *(above)* displays stars, planets, asteroids, and comets accurate in position to an *arc-second* level, the most precise position display of any sky software yet developed.

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Send for your free copy of **Meade Bulletin 2000.** See why, if you're serious about astronomy, Meade Epoch 2000sk is the only sky software to use!

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MEADE

TELESCOPES AND ACCESSORIES

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Series 4000™ Super Plössls 52°

Meade 4-element Super Plössls, updated and redesigned to utilize the latest in optical glass-types, are the finest general-purpose eyepieces available. For observing hairline lunar and planetary detail, splitting close doubles, or for deep-space; guaranteed to deliver more contrast and image sharpness than any other brand. Rubber eyeguards fold down for eyeglass wearers–a feature not available on competing brands. Multi-coated. All focal lengths through 32mm are parfocal.

Super Plössls (SP; 4-elements; 1.25"; 52°):
6.4, 9.7, 12.4, 15, 20, 26mm each: **$87.95** (3.45)
32mm (52°); **40mm** (44°) each: **109.95** (3.79)
56mm (52°; 2") **229.95** (5.48)

Series 4000™ f/6.3 Focal Reducer/ Field Flattener

f/6.3 FOCAL REDUCER/FIELD

Manufactured to exclusive Meade optical designs; threads on to any Meade or Celestron Schmidt-Cassegrain rear cell and converts f/10 scopes to f/6.3 (or f/6.3 SCT's to f/4), while significantly flattening the field. Use with SCT visual or photo accessories. Actual visual field is increased by 56%, for fine wide-field views of star fields and nebulae. In astrophotography, reduces exposure times by about 50%, while producing an actual field diameter of 1.5" at the film plane. A tremendous aid with CCD imagers in reducing image size for locating and centering images on CCD chips. 4-element optics; multi-coated; 41mm clear aperture.

$129.95 (3.60)

World's Most Advanced Illuminated Reticle Eyepiece

Series 4000 Plössl 9mm, with rubber eyecup and micrometric X-Y positioning of the reticle within the field. Greatly facilitates locking on the guide star. Sharp high-power imaging, excellent eye relief. Wireless red LED illuminator with adjustable brightness control. **Internal batteries included.** Multi-coated optics. Bullseye reticle. 1.25"

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Series 4000 Plössl 9mm—Same as above but with 6 ft. cord and plug for Meade LX3, LX5, LX6, LX100, LX200, and APO power panels, in place of wireless illuminator.

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Series 4000™ Super Wide Angle 67°

For exquisite wide-angle images at low-to-medium powers, ideal for star fields, galaxies, and other deep-space phenomena. SWA 13.8, 18, and 24.5mm are superb complements to the #140 Barlow, above.

Super Wide Angle (SWA; 6-elements; 1.25"; 67°)–**13.8mm: $159.95** (3.49); **18mm: 169.95** (3.69); **24.5mm: 199.95** (3.89); **32mm** (2"): **279.95** (4.78); **40mm** (2"): **339.95** (5.48)

Series 4000™ Ultra Wide Angle 84°

The ultimate eyepieces; extreme image sharpness over an amazing 84° field.

Ultra Wide Angle (UWA; 8-elements; 1.25"; 84°)–**4.7mm: $179.95** (3.29); **6.7mm: 219.95** (3.29); **8.8mm** (1.25"/2"): **269.95** (4.78); **14mm** (1.25"/2"): **329.95** (5.48)

Camera Adapters

Professional-quality adapters for rigid coupling of telescope-to-camera. Use for either Eyepiece-Projection or Prime Focus. Precision-machined of aluminum and brass, threaded for filters. Use with T-mount, available separately.

.965": $27.95; **1.25": $29.95** (2.98)

Variable Tele-Extender

For eyepiece-projection photography with any Meade or Celestron SCT. Threads on to eyepiece-holder. Sliding cell with lock permits wide range of projection magnifications with the same eyepiece. Use with T-mount for your camera.

$39.95 (2.98)

Variable-Projection Camera Adapter (1.25")

Machined sliding cell allows variable projection power in eyepiece-projection photography; permits precise selection of correct photo power in lunar and planetary photography; threaded for filters. Use with T-mount for your camera.

$39.95 (2.98)

T-Adapters for SCT's

Rigidly couples camera to telescope for prime focus photography with any Meade or Celestron Schmidt-Cassegrain. Use with T-Mount for your 35mm camera.

$26.95 (2.98)

Meade Model 285 60mm f/15 Equatorial Refractor

Complete with tripod and 2 eyepieces.

Includes the same equatorial mount of larger Meade models at right. Dual-axis worm-gear slow-motion controls permit easy tracking of astronomical objects. Two eyepieces (1.25") for powers of 36X and 100X. Multi-coated objective lens resolves to the theoretical limit.

Accepts #531 Motor Drive *(below)*

$299 (16.55)

Meade Model 4500 4.5" f/8 Equatorial Reflector

World's largest-selling 4.5" telescope!

The finest first-telescope available. *Provides stunning optical performance on the Moon, planets, and hundreds of deep-space objects.* Precision equatorial mount includes worm-gear slow-motion controls in RA and Dec and full-length (50") aluminum tripod. 6 x 30 finder, rack-and-pinion focuser (1.25"), multi-coated MA 25mm eyepiece (1.25"). *Immediate delivery through your authorized Meade dealer.*

Fully automatic tracking with #531 Motor Drive *(below)*

$399 (22.40)

Meade Model 390 90mm f/11 Altazimuth Refractor

Perfect for land-viewing or astronomy.

Excellent imaging power for any terrestrial application, or for observing hundreds of astronomical objects in sharp detail. Smooth dual-axis controls; multi-coated optics. Supplied with 6 x 30 finder, MA25mm eyepiece (1.25"), aluminum tripod.

Includes flexible steel cable controls on both axes.

$499 (23.60)

Meade Model 395 90mm f/11 Equatorial Refractor

Multi-coated, high-resolution optics.

Includes flexible steel cable controls on both axes.

Accepts #531 Motor Drive *(below)*

Precision Meade objective lens far surpasses other telescopes selling at similar prices. Complete with equatorial mount, aluminum tripod, 6x30 finder, MA 25mm eyepiece (1.25"). Thousands now in use.

$599 (24.65)

Meade intermediate-size telescopes are the world's largest-selling quality telescopes of their apertures. *They are the only telescopes in this price range designed by Meade engineers and manufactured to exclusive Meade specifications.* Each instrument includes mechanical components, gear systems, and accessories specifically intended for serious applications of the beginning to intermediate amateur astronomer. American-size 1.25" barrel-diameter eyepieces, threaded for filters, are included with all models. Large cable controls facilitate the tracking of astronomical or terrestrial objects, and, on equatorial models, the optional Meade #531 Motor Drive *(see right)* enables fully automatic tracking of astronomical objects.

#531 Motor Drive

Attaches in seconds to the equatorial mounts of Meade Models 285, 4500 or 395 telescopes. Permits fully automatic tracking of celestial objects. Cordless operation anywhere in the world from 3 (user-supplied) AA batteries. **$99.50** (4.78)

HOW TO ORDER

- Prices shown are suggested USA mail-order retail prices and do not include any applicable sales taxes.
- Suggested shipping and handling charges to the 48 states by UPS or US Mail shown in ( ) next to each price.
- Meade accessories may be ordered from any Meade Advanced Products Dealer. **The following national mail-order dealers carry all Meade accessories in-stock for immediate shipment:**

ASTRONOMICS, Norman, OK.
Orders: 800-422-7876; Info.: 405-364-0858.

CALIFORNIA TELESCOPE CO., Burbank, CA.
Orders & Information: 818-505-8424.

CITY CAMERA, Dearborn, MI.
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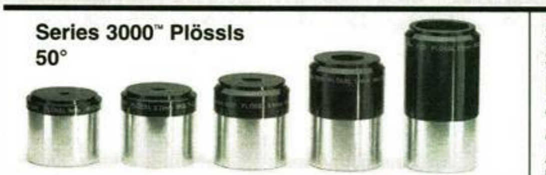
Orders & Information: 416-783-4140.

Series 3000™ Plössls 50°



The very latest in eyepieces from Meade optical designers, new Meade Series 3000 Plössls yield the finest image corrections obtainable from the classical 4-element Plössl design. Available in a wide range of focal lengths from 5mm through 25mm. All five eyepieces are parfocal, so that, at most, only slight refocusing of the image is necessary from eyepiece to eyepiece. Unlike competing moderately-priced Plössls, Meade Series 3000's are **multi-coated** for maximum light transmission and image contrast. Chrome-plated brass barrels are threaded for standard filters. Manufactured exclusively for Meade Instruments by one of Japan's leading lensmakers, Series 3000 Plössls produce excellent results on reflectors, refractors, and Schmidt-Cassegrains of any focal ratio.

Series 3000 Plössls (4-elements; 1.25"; 50°)
5, 6.7, 9.5, 16, 25mm each: **$49.95** (3.45)

Series 3000™ Plössl 40mm 44°

A perfect complement to the Series 3000 Plössls at left, this all-new Plössl 40mm produces spectacular low-power, wide-field results with any telescope. Includes classical 4-element Plössl optics, multi-coated. Barrel dia. 1.25"; threaded for filters. Apparent field: 44°.

$79.95 (3.79)

MA12mm Illuminated Reticle Eyepiece

Excellent 3-element optical system, long eye relief, fully coated, with double crossline reticle. Wireless red LED illuminator and variable brightness control. **Batteries included.**

$99.95 (3.45)

As above but with 6 ft. cord and plug for Meade telescopes with power panels, in place of wireless illuminator. **$79.95** (3.45)

Modified Achromatic Eyepieces

Meade 3-element MA eyepieces yield sharp, well-corrected images on the Moon, planets, and deep-space at a reasonable price. Multi-coated; threaded for filters; 1.25" barrel diameter. Apparent field: 40°. **MA 9, 12, 25, 40mm.**

each: **$37.95** (2.98)

2x-3x Variable Barlow (1.25")

#127: Precision internal sliding lens assembly permits continuously variable power settings between 2x and 3x. Engraved scale indicates power in use. Yields bright, sharp, high-contrast images on telescopes of all types. Multi-coated; 1.25". **$59.95** (3.45)

2x Short-Focus Barlow (1.25")

#126: Only 2.5" long, the #126 works well with any telescope accepting 1.25" eyepieces, even those with limited focus range. Maintains the high image quality of the #122, at right. Insert the #126 into star diagonal for 2x or insert star diagonal into #126 for 3x. 26mm clear aperture. Multi-coated. **$47.95** (3.45)

2x Telenegative Barlow (1.25")

#122: Doubles eyepiece power with sharp, high-resolution, high-contrast imaging on telescopes of all types. 27mm dia. (26mm clear aperture). Excellent corrections for chromatic and spherical aberrations at all photo-visual wavelengths. Multi-coated. 1.25" **$47.95** (3.45)

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FREE! $800 CCD Equipment System!

Now, for a limited time, when you purchase a Meade Pictor 416 or 1616 CCD imager at the regular price, **we'll include an $800 Meade CCD Equipment System—everything you need for advanced CCD imaging—absolutely FREE!** Purchased separately, the CCD Equipment System is priced at $807 and includes these important products:

Meade Pictor 201 Autoguider: Allows completely automatic guiding of your Pictor camera during CCD imaging or your 35mm camera during long-exposure astrophotography.	$395.
Meade CCD Off-Axis Guider System: Complete with adapters for 1.25" *eyepiece* holders and for Schmidt-Cassegrain rear-cell threads. Use with the Pictor 201 on guide stars to 10th-magnitude.	119.
Meade CCD Image-Orientation Adapter: Threads into the Off-Axis Guider and permits precise image orientation on the CCD chip.	35.
Meade Epoch 2000ip Image Processing Software: Professional Windows-based image processing that permits the enhancement and analysis of CCD images using the most advanced techniques, including dynamic scaling, histogram equalization, image convolution, unsharp masking, median filtering, RGB merging, and more.	199.
Meade Foam-Lined Carrying Case (19" x 14" x 7"): Provides for secure storage and transport of your Pictor 416 or 1616 CCD imager as well as all items of the CCD Equipment System described above.	59.
Total price of all items if purchased separately:	**$807.**

The Meade Pictor 416 CCD Imaging Camera is packed, at no additional charge, with the **Meade $800 CCD Equipment System** during the period of this special offer.

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The Trifid Nebula (M20): Pictor 1616; a 5-minute exposure by Jack Newton with the Meade 7" f/9 *ED* Apochromatic Refractor.

Pictor 201 Autoguider: For flawless, ultraprecise autoguiding during long-exposure astrophotography or CCD imaging. Automatically locks on to guide stars as faint as 10th-magnitude and makes all required dual-axis corrections. Results in perfectly guided astrophotographs or CCD images during even the longest of exposures. Completely self-contained; no host PC required. **$395.** + $10 packing & shipping in 48 states.

Pictor 208 Autoguider/Imager: For an amazingly low price, the 208 gives impressive imaging capability even to the novice. On telescopes of 4" aperture and larger, the Pictor 208 yields very satisfying results and, in addition, is a full-capability autoguider, containing the exact same autoguider hardware and software as the Pictor 201, above. The 208 incorporates the Texas Instruments TC-255 microchip, by far the largest, highest-resolution chip available in any CCD unit in its price range. **$795.** + $15 P & S

Pictor 216 CCD Autoguider/Imager: Identical in operation and size to the 208, the Pictor 216 includes a 16-bit A/D converter for 65,536 brightness levels. The result is a level of image quality only obtainable on competing units that sell for almost twice the 216's price. Combining high-resolution imaging with low dark current, the Pictor 216 satisfies the long-term CCD imaging requirements of the majority of serious amateurs. **$1295.** + $15 P & S

Pictor 416 CCD Autoguider/Imager: Armed with the powerful Kodak KAF-0400 CCD microchip, the Pictor 416 is the most advanced high-resolution CCD system available under $5000. And, with its standard-equipment SCSI interface, the 416 can full-frame download in *one second!* The Pictor 416 is a powerful CCD system on any telescope; attached to a Meade LX200, its capabilities are truly awesome. The auto-mosaic feature, for example, permits the imaging of an arbitrarily large sky area **automatically** on user command. **$2495.** + $25 P & S

Pictor 1616 Autoguider/Imager: For professional-level applications the Pictor 1616 utilizes the Kodak KAF-1600 microchip, one of the largest (13.80 x 9.20mm) CCD chips in commercial production. Identical in pixel density and dark current to the 416, but with *four times* the chip area, the 1616 permits the imaging of very large sky areas: a sky area of 23' x 15' with an 8" f/10 Schmidt-Cassegrain, almost one-half the lunar surface in a single exposure. The 1616 is the finest CCD imaging system available at under-$10,000. **$6495.** + $40 P & S

The special Meade CCD Equipment System offer is effective beginning July 20, 1995, at participating Meade dealers in the U.S.A. and Canada. *This offer is valid until further notice and may be withdrawn at any time.* ■ All prices shown are suggested U.S. national mail-order retail prices, exclusive of sales taxes or credit card charges, if applicable. ■ For safety reasons AC-powered personal computers should be used indoors only. ■ The Meade brochure ***CCD Imaging Made Simple*** is available free of charge, or send $3.00 for the 76-page Meade ***1995 General Catalog.***

AUTHORIZED U.S. MAIL-ORDER DEALERS

ASTRONOMICS, Norman, OK, Orders: 800-422-7876; Information: 405-364-0858

CALIFORNIA TELESCOPE COMPANY, Burbank, CA
Orders & Information: 818-505-8424

CITY CAMERA, Dearborn, MI, Orders: 800-359-5085; Information: 313-846-3922

FOCUS CAMERA, Brooklyn, NY, Orders: 800-221-0828; Information: 718-436-6262

LUMICON, Livermore, CA, Orders: 800-767-9576; Information: 510-447-9570

SHUTAN CAMERA & VIDEO, Chicago, IL, Orders: 800-621-2248;
Illinois & Information: 312-332-2000

Canada:

EFSTONSCIENCE, Toronto, Ontario, Orders & Information: 416-787-4581

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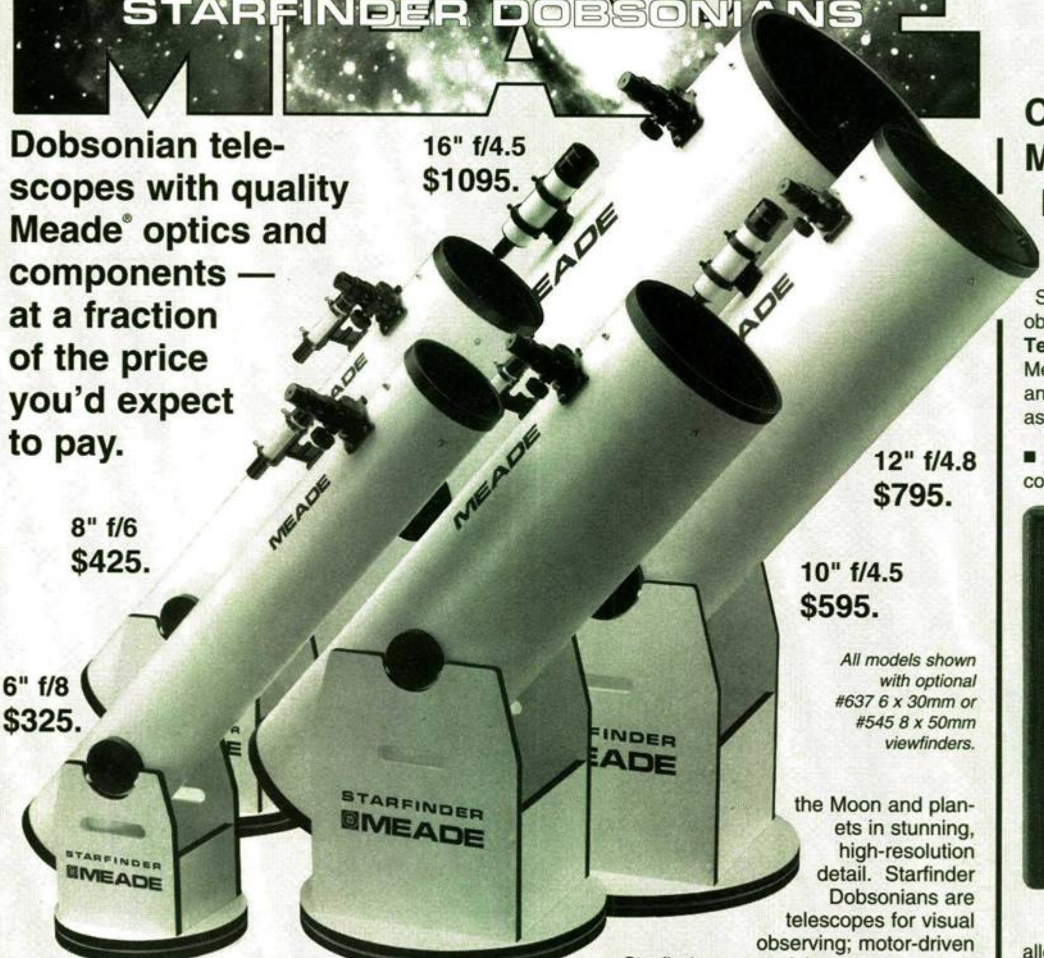
MEADE STARFINDER DOBSONIANS

Dobsonian telescopes with quality Meade® optics and components — at a fraction of the price you'd expect to pay.



16" f/4.5 $1095.

12" f/4.8 $795.

10" f/4.5 $595.

8" f/6 $425.

6" f/8 $325.

All models shown with optional #637 6 x 30mm or #545 8 x 50mm viewfinders.

Compare *feature-for-feature* with other similarly priced Dobsonians!

- **Primary and Secondary Mirrors of Low-Expansion Pyrex® Glass:** Unlike the plate glass optics of other Dobsonians that can become thermally unstable (especially in larger apertures), Meade Dobsonians are made of Grade-A, fine-annealed Pyrex—the exact same professional-quality optics used on Meade Starfinder Equatorials.
- **Precision Components:** Including a full-size rack-and-pinion focuser (1.25") with 2.6" travel and fully-adjustable *4-vane* secondary mirror system.
- **Rigid, Durable, Beautiful Dobsonian Mountings**, manufactured of cabinet-quality materials, provide extremely smooth motions of the telescope in both altitude and azimuth. Both telescope axes ride on zero-backlash Teflon/Nylon bearings, facilitating the location and tracking of celestial objects.
- **Optical Tubes:** Starfinder Dobsonians include the same strong, spiral-wound optical tubes used on Starfinder Equatorials *(right).* All telescopes include a multi-coated MA25mm eyepiece; each tube is factory pre-drilled for the optional 6 x 30mm or 8 x 50mm viewfinder.
- **Performance!** A Meade Starfinder Dobsonian or Equatorial opens up the skies to an extremely wide range of serious visual observing: all 110 Messier objects, thousands of NGC objects—nebulae, galaxies, star clusters, in all their variations of form, color, and extent, as well as the Moon and planets in stunning, high-resolution detail. Starfinder Dobsonians are telescopes for visual observing; motor-driven Starfinder equatorials may be used, in addition, for lunar and planetary photography and even for limited deep-space photography.

Packing and UPS Shipping Charges to any address in the 48 states: 6"–$39; 8"–$49; 10"–$69; 12.5"–$79. 16"–$45 packing, shipped truck freight collect.

ACCESSORY OFFER!

At the time you order any Meade Dobsonian, you can buy 2 additional multi-coated eyepieces, MA9mm and 12mm, *and* the Meade #637 6 x 30mm viewfinder with metal bracket for a **total of $49.95!** *Purchased separately, the 2 eyepieces and viewfinder sell for $125.85!* Offer valid until further notice.

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LUMICON, Livermore, CA.
Orders: 800-767-9576; Info.: 510-447-9570.

SHUTAN CAMERA & VIDEO, Chicago, IL.
Orders: 800-621-2248; Illinois & Info.: 312-332-2000.

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EFSTONSCIENCE, Toronto, Ontario.
Orders & Information: 416-787-4581.

KHAN SCOPE CENTRE, Toronto, Ontario.
Orders & Information: 416-783-4140.

STARF COMP

Computerize your Meade® Starfinder™ Dobsonian or Equatorial for only $295!

Spend your time **observing, not searching** for objects! **With the incredible Meade Magellan™ Telescope Computer System** attached to your Meade Starfinder Dobsonian or Equatorial, finding any of **12,218 celestial objects** is almost as easy as pointing the telescope.

MEADE
ENTER
MODE
PREV
NEXT
ON
MAGELLAN I
TELESCOPE COMPUTER SYSTEM
U.S.A.

Actual Size: 4" x 5" x 1.25"

- Don't spend $400, $500, or $600 for a computer system with fewer features! Designed and manufactured at the Meade Irvine facility, the Magellan I includes one of the largest object databases available, incorporates only premium-grade components, and sells for a low $295!
- **Easy to Use!** Just input the R.A. and Dec. of the object you wish to observe, or call up an object from Magellan's massive database. Magellan allows you to slew the telescope manually to the object and place it in the visual field, quickly and precisely.
- **Fast 2-Star Alignment:** Point the telescope at 2 bright stars selected from the star database, and the computer is aligned in *seconds.* No need to input time or date, latitude or longitude. Magellan's powerful microprocessor calculates telescope position in milliseconds and directs your movements of the telescope for fast, accurate object location.

Meade Magellan II Computer-Corrector for Starfinder Equatorials

Plug the Magellan II into the control panel of your Meade DC-powered Starfinder Equatorial *(right)* and you have *all the capabilities of the Magellan I (above)* ***plus*** a 4-speed, dual-axis, drive-corrector/microslewing system!

Includes: Magellan II hand controller *(right)* with 4 dual-axis speed rates (2x, 8x, 16x, 32x sidereal); high-resolution 4096-pulse encoders for both axes; electric Declination control system; 12,218-object computer database; 2-star alignment; RS-232 serial interface. (For Meade *DC-powered* Starfinder Equatorials, only.)

#2018: for Starfinder Equatorial
6", 8", or 10" . . . . $495.
#2019: for Starfinder Equatorial 16" . . . 595.

Prices plus $20 packing & shipping in the 48 states.

INDER
UTERS

■ **High-Resolution 4096-pulse Encoders:** Each Magellan system includes two premium-grade, high-resolution encoders. Encoder precision is 5.3 arc minutes.

■ **Large 32-Character LCD Red-Backlighted Display:** The same LCD display included with the Meade LX200 hand controller. Includes variable illumination from dim to bright.

■ **12,218-Object Database:** A database that includes an amazing array of objects:

7,840	NGC objects; the complete NGC catalog
4,093	IC objects from the Index Catalog
125	user-defined objects
110	Messier objects; the complete catalog
42	alignment stars for the Magellan system
8	major planets, from Mercury to Pluto
12,218	objects, total

■ **Supplied Complete!** With other computers you pay *once* for the basic controller and then pay *again* for the "Encoder Installation Package." Meade Magellan Systems are supplied **complete** with: controller/display unit (4" x 5" x 1.25"); encoders for both telescope axes; RS-232 serial interface; bracket for convenient placement of the controller on the telescope tube; and attachment hardware. Just add the user-supplied 9v. transistor radio battery, and Magellan is ready to use. First-time installation is quick and simple.

Meade Magellan I
Telescope Computer Systems

#2010:	**for Meade Starfinder Dobsonian 6", 8", 10", 12.5", or 16"**	**$295.**
#2011:	**for Meade (DC-powered) Starfinder Equatorial 6", 8", or 10"**	**295.**
#2012:	**for Meade (DC-powered) Starfinder Equatorial 16**	**295.**

All prices plus $15 packing & shipping in the 48 states. Prices shown are suggested U.S. national mail-order retail prices. For additional information on Meade Magellan systems, send for your free copy of **Meade Bulletin 2900.**

MEADE
MAGELLAN II
COMPUTER - CORRECTOR
ENTER
MODE
FIND
N
E
W
S
32X 7
8
M 9
16X 4
5
STAR 6
8X 1
2
CNGC 3
2X 0
PREV
NEXT
U.S.A.

MEADE
12VDC
On
R.A. Encoder
MEADE DC DRIVE SYSTEM

MEADE STARFINDER EQUATORIALS

Battery-powered motor drives for fully cordless operation!

16" f/4.5 $2495.

10" f/4.5: $799.95

8" f/6: $699.95

6" f/8: $599.95

Standard equipment on 6", 8", and 10" equatorial models includes:

■ **Superb Optical System:** Includes hand-figured, parabolic primary mirror and elliptical flat secondary, both of Grade-A Pyrex glass. Optics are multi-coated and meet the theoretical limits of resolution.

■ **Precision Equatorial Mount:** Manufactured of machined aluminum to tolerances of .001" or better, with 4"-dia. pier and die-cast tripod legs for rock-solid support of the optical tube. Moves effortlessly from object to object on precision bearing surfaces. Polar and Dec. shafts are 1" solid steel. Setting circles on both axes.

■ **Battery-Powered Cordless Drive System!** Provides fully automatic tracking of celestial objects. Operates for more than 50 hours from 4 (user-supplied) AA-size batteries inserted through the drive cover. Control panel *(see inset, above)* also permits powering of telescope from 12v. auto cigarette lighter plug, using optional 25' cord.

■ **Accessories and Components:** Rack-and-pinion focuser (1.25") with 2.6" travel; #637 6 x 30mm viewfinder; multi-coated MA25mm (1.25") eyepiece; strong, durable, spiral-wound optical tube with attractive white finish.

■ **Starfinder Equatorial 16:** Includes equatorial mounting with 1.5" steel shafts, Sealmaster ball bearings, 6"-dia. pier, 4 x AA-size battery-powered worm gear drive, 8 x 50mm viewfinder, #682 giant (2" & 1.25") rack-and-pinion focuser.

Packing and UPS Shipping Charges to any address in the 48 states: 6"–$65; 8"–$75; 10"– $90. 16"–$55 packing, shipped truck freight collect.

To Order: Contact your authorized Meade Advanced Products Dealer. All prices shown are suggested USA mail-order retail prices.

Meade 1995-96 General Catalog, $3.00 postpaid, is available from your authorized Meade dealer or directly from Meade Instruments.

ACCESSORY OFFER!

At the time you order any Meade Starfinder Equatorial Telescope, you can buy 2 additional multi-coated eyepieces, MA9mm and 12mm, for a **total of $29.95!** *Purchased separately, the 2 eyepieces sell for $75.90!* Offer valid until further notice.

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MEADE
MEADE 127ED/APO EMC
Meade LXD 650 U.S.A.

Meade Model 127ED:
5" *ED* Apochromatic Refractor.
Shown with optional #1697 Computer Drive System.

Background image: **the Omega Nebula (M17) —**
A 5-minute image by Jack Newton using the Meade 7" *ED* Apochromatic Refractor and Meade Pictor 1616 CCD Imager.

ED APOCHROMATIC REFRACTORS

"This is the best black-and-white CCD image of M17 that I have ever taken with any telescope. I just couldn't believe that this could be done in a 5-minute shot with a CCD camera and a 7" refractor. I'm amazed at how the telescope performs, even against my own 25" Newtonian." **—Jack Newton**

Fortunate indeed is the observer with a Meade *ED* Apochromatic Refractor at his or her disposal, for these are professional-class instruments capable of serious research. Observe structural detail and color variations within Jupiter's Red Spot and at the boundaries of 8 to 10 cloud belts; resolve all three of Saturn's main rings and substructures within the rings themselves. *Simply put, if you're looking for the finest, textbook-perfect, ultra-high-resolution, high-contrast imaging of the skies that astronomical instrumentation, of any type, can provide, then a Meade ED Apochromatic Refractor is for you.*

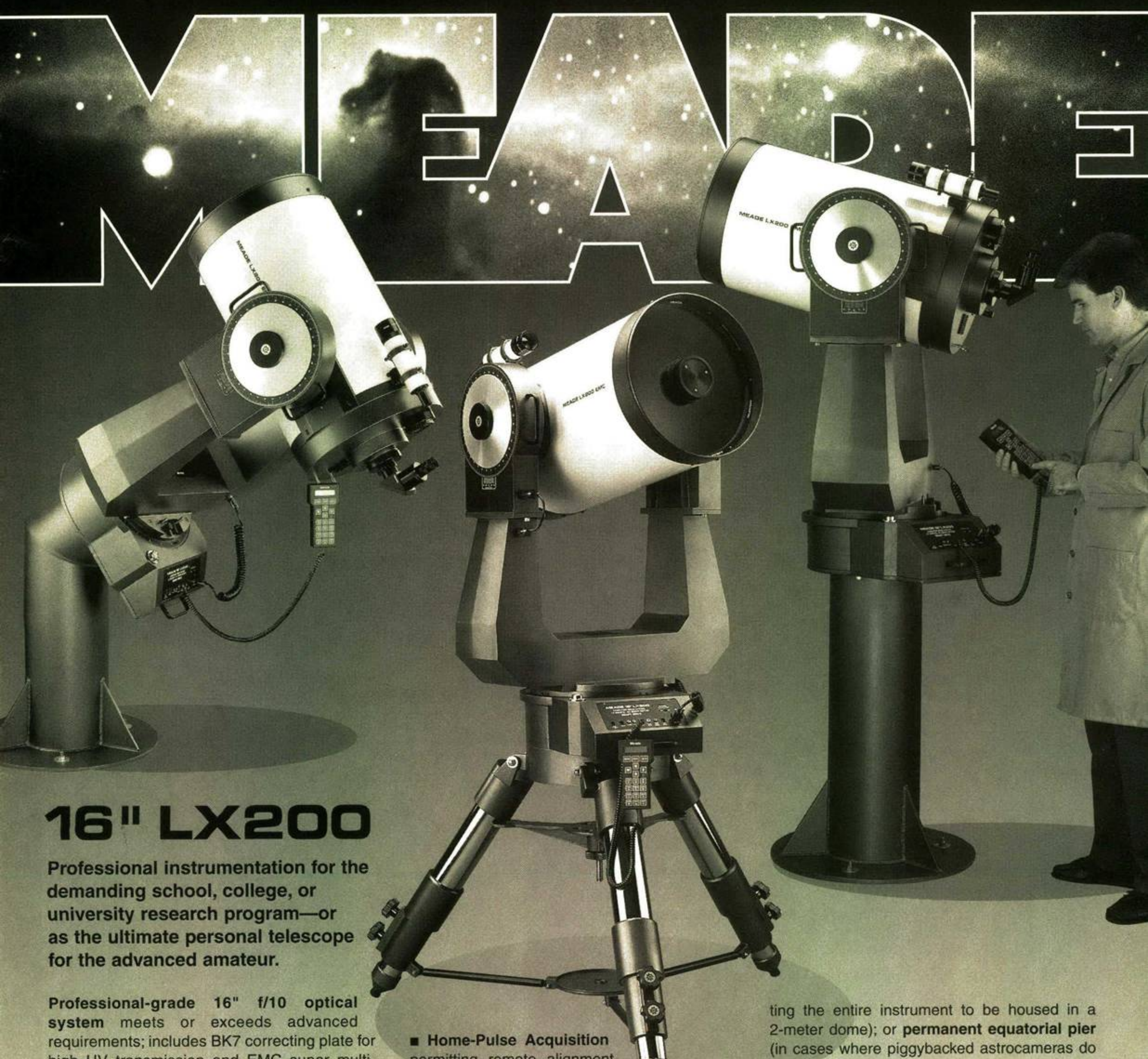
Use the massive Meade **LXD 650** (4", 5") or **LXD 750** (6", 7") equatorial mounts in conjunction with the optional **#1697 Computer Drive System** to slew the telescope across the sky and computer-point the instrument, automatically, *to a precision of one arc-minute.* ***Meade LXD mounts are the only commercially-available German-type mounts capable of such a feat.*** Actuate any of 9 pushbutton-controlled drive speeds (from 2x photoguide to 8°/sec. fast-slew) on both axes, automatically, to locate and center any object directly from its input R.A. and Dec. Or use the onboard database for even faster object centering. Included with the #1697 CDS, the Meade **Smart Drive**™ assures the extremely low periodic error essential to research-level photographic or CCD imaging.

More than 40 Meade optional accessories are available to suit virtually any observing, photographic, or CCD imaging requirement.

Supplied complete per catalog specifications:

4" f/9 Model 102ED	**$2495.**
5" f/9 Model 127ED	**2995.**
6" f/9 Model 152ED	**4495.**
7" f/9 Model 178ED	**5495.**
#1697 Computer Drive System	**695.**

Packing and shipping in the 48 states: 4"—$105; 5"—$125; 6"—$185; 7"—$215.



16" LX200

Professional instrumentation for the demanding school, college, or university research program—or as the ultimate personal telescope for the advanced amateur.

Professional-grade 16" f/10 optical system meets or exceeds advanced requirements; includes BK7 correcting plate for high UV transmission and EMC super multi-coatings. ■ **Massive one-piece fork mount** permits substantial auxiliary equipment to be piggybacked with rock-solid stability. ■ **Large 11" worm gears** on both axes, with factory-programmed Smart Drive™; periodic error less than 5 arc seconds. ■ **Automatic GO TO capability** to any object in the onboard 64,350-object database or to any input R.A. and Dec. ■ **High-Precision Pointing™** to within one arc-minute in the GO TO mode. ■ **DC servo drive systems** with integrated encoders and planetary gearboxes; encoder resolution: 0.13 arc secs. ■ **Six pushbutton-controlled drive-speed rates,** from photo-guide to fast-slew on both axes, simultaneously. ■ **Micro-processor controlled sidereal-rate tracking** in AZ or EQ modes with quartz accuracy. ■ **Home-Pulse Acquisition** permitting remote alignment and operation through a modem link to the telescope's RS-232 interface. ■ **Control panel connectors** for optional systems including CCD autoguiders and imagers, electric focuser, and the Meade **#1222 Field De-rotater** for long-exposure astrophotography in the AZ mode. ■ Available with **supergiant transportable field tripod** (2-person field set-up in less than 10 minutes); **permanent altazimuth pier** (permitting the entire instrument to be housed in a 2-meter dome); or **permanent equatorial pier** (in cases where piggybacked astrocameras do not permit field de-rotation).

The Meade 16" LX200 is in continuous production at the Meade Irvine, Calif. factory. **Delivery time:** 4 to 12 weeks. **Price:** $14,950, complete with supergiant field tripod, plus $385 packing and shipping in the 48 states; prices slightly higher with permanent altazimuth or equatorial pier.

For your copy of the all-new **1995 Meade General Catalog** ($3.00), write Meade Instruments or contact your authorized Meade Advanced Products Dealer.

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typical example of the most recent asteroid paranoia. Let's be realistic: All of our theories about catastrophic extinctions by asteroid impacts are just that — theories. Contrary to the doomsday scenarios, the impact effects might be devastating for an area of just a few hundred kilometers across. — *Alexander A. Berezin, McMaster University, Hamilton, Ontario, berezin@mcmaster.ca*

There Goes the Neighborhood. . .

Professor Djorgovski's informative article on quasars, "Fires at Cosmic Dawn" (September 1995), raised a question in my mind. On page 43 the author stated that the reignition of a possible defunct quasar in the center of the Milky Way would appear as an intense blue star in Sagittarius that would be "great (if brief) fun for astronomers."

Did Professor Djorgovski wish to imply that this event would be lethal to terrestrial life? Would such an event be lethal to all life that happened to exist in a galaxy undergoing such a reignition event? — *Terence McKenna, Honaunau, Hawaii, syzygy@ilhawaii.net*

— The type of destruction that might result from a reawakened quasar central engine would vary greatly and depend entirely on the amount of matter falling into the quasar's central black hole. There would likely be no effects far out from the Galaxy's center. Close in, and in the path of supersonic polar jets, stars, planets, and inhabited worlds might be incinerated in a sudden maelstrom.

Hip To Be Dark?

Thanks for your great coverage of light pollution ("How to Beat Light Pollution," September 1995). In Connecticut we have just passed a bill for the replacement of all lighting fixtures for state secondary and service roads with full cutoff fixtures (when the lights are due for replacement). The state highways will be considered for the same treatment, but ultimately they fall under the jurisdiction of the Department of Transportation. This victory was won largely from the efforts of five people. Though most of the astronomy clubs around the state were contacted and urged to motivate their members, there was little response.

I've come to the realization that we as a society are not motivated to do something unless it's considered "hip." This translates to someone or some organization of established repute publicly stating that it's okay to do this or that. Once the public hears about something being okay for the third or fourth time then it becomes the latest rage and you are an out-of-touch loser if you're not involved. The fight against light pollution desperately needs to be considered hip.

I've found that amateur astronomers generally believe that light pollution is too big a problem to take on, and they end up doing nothing. The reality is that politicians never get any letters about light pollution. As a result, they're completely unaware of the problem. And if a bill comes up, they don't know of anyone who cares, so why should they vote for it?

Please cover this area as frequently as possible and help amateurs to learn that they really can do something. — *Bob Crelin, Branford, Connecticut*

Discovering Taygeta's Companion

Your story "Moon Reveals New Stars" (AstroNews, April 1995) contains an error. You reported that seven new binary stars were discovered by astronomers at the Max Planck Institute in Germany by observing a lunar occultation in 1994. One of these mentioned was Taygeta (19 Tauri).

However, I discovered Taygeta's binary companion during a grazing occultation on August 6, 1969. At the time I was employed at the U.S. Naval Observatory in Washington and led a team of observers who joined a local group in the Kansas City area. Taygeta made a spectacular series of "stair step" dimmings and brightenings. At times, we observed both the primary and the companion stars separately. We obtained a total of 99 timings and from these several staff astronomers made surprisingly accurate determinations of the magnitude of the secondary, the separation, and the position angle.

The observation was reported to Brian Marsden of the International Astronomical Union and the discovery was documented on IAU *Circular* 2168 on September 16, 1969. — *Harold Povenmire, Canaveral Area Graze Observers, Indian Harbour Beach, Florida* □

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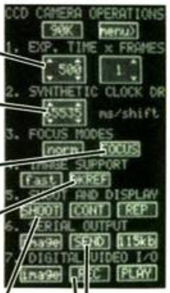

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ASTRO FORUM

The View from Mount Hamilton

by Thomas A. Dobbins

The following is an account of author and amateur astronomer Tom Dobbins' experiences at Lick Observatory the week of August 7-13, 1995. Dobbins was in the company of psychiatrist Bill Sheehan, author of Worlds in the Sky *and* Planets and Perception*; David Graham, the director of the Saturn Section of the British Astronomical Association; and Stephen O'Meara, an editor-at-large for* Sky and Telescope *magazine and a freelance writer.*

Stepping into the dome of Lick Observatory's 36-inch refractor for the first time is like stepping into a cathedral. Although the battleship-gray coat of paint appears dull and weathered on the telescope's great tube, this behemoth, commissioned in 1888, has a majesty and romance that modern instruments lack. One certainly feels a strong sense of purpose when perched at the end of a riveted boilerplate tube stretching 58 feet skyward.

Ostensibly, our purpose this week is to observe Saturn at ring-plane crossing and to inspect the other gas giants of the solar system. Thanks to patient instruction and a night of supervision provided by Remington Stone of the Lick Observatory staff, we soon gain a comfortable familiarity and confidence when directing the telescope's moving mass of some 13 tons.

"Rem," as he is known, is a research astronomer who has lived on the mountain for 28 years. After service as a Marine Corps fighter pilot, he spent a year studying Zen archery in Japan. This probably accounts for his gentle, reserved manner and tranquil air — unusual qualities in a Marine.

To our disappointment and even alarm, seeing never exceeds mediocre on the windy first night of our observing run. As I step from the eyepiece and make a disparaging remark about the state of the atmosphere, Graham scolds me by quoting the color sergeant in the memorable film "Zulu" (about the battle at Rorke's Drift, Natal in 1879): "Come along, there's a good gentleman. Don't upset the lads."

Fortunately, all five subsequent nights feature intervals of superb seeing that permit a magnification of 1,176x on several occasions, although 588x is customary. We feel it is our duty not to let the telescope sit idle, even for a moment. Thus, by midweek, our observing run also becomes a study in the effects of sleep deprivation.

On two exquisitely steady mornings the city lights scattered below Mount Hamilton lie enshrouded in a layer of fog that looks eerily like the surface of a vast body of water in the moonlight, complete with hilltop "islands" protruding. Full Moon occurs on August 10, and the sky is brightly illuminated throughout the week. Transparency, however, remains excellent. A thumb held up to occult the Moon seldom reveals even a trace of light scatter by haze or dust.

The slit of Lick's 90-ton dome is opened daily after public tours end at five o'clock to permit the telescope and its surroundings to cool down. By eight o'clock in the evening the great refractor is swung toward Jupiter, which is readily visible to the naked eye just before sunset. Until the planet sinks close to the southwestern horizon almost two hours later, the tranquillity of the atmosphere at twilight often rivals the best moments that would follow in the hours after midnight.

Jupiter presents such a welter of intricate detail that any attempt to make more than a cursory, impressionistic sketch of the entire disk is futile. The southern temperate latitudes are dotted with a host of "white-oval" convection cells poking through the sooty haze left by the July 1994 comet impacts. Structure within the Great Red Spot is discernible, and the Galilean satellites appear as disks of differing size and brightness.

One evening we witness Io transiting Jupiter. As it approaches the planet's limb it appears as a tiny, well-defined disk. Once it is seen against the cloud-deck backdrop, however, the satellite dramatically transforms into a bright rectangular bar with its major axis parallel to Jupiter's equator. Io's dusky poles are all but indistinguishable from the darkened limb regions of Jupiter, but its more reflective equatorial region stands out prominently. Even these disappear, however, when it approaches the Jovian disk's brightened central meridian.

As Jupiter sets and we wait impatiently for Saturn to gain elevation, the

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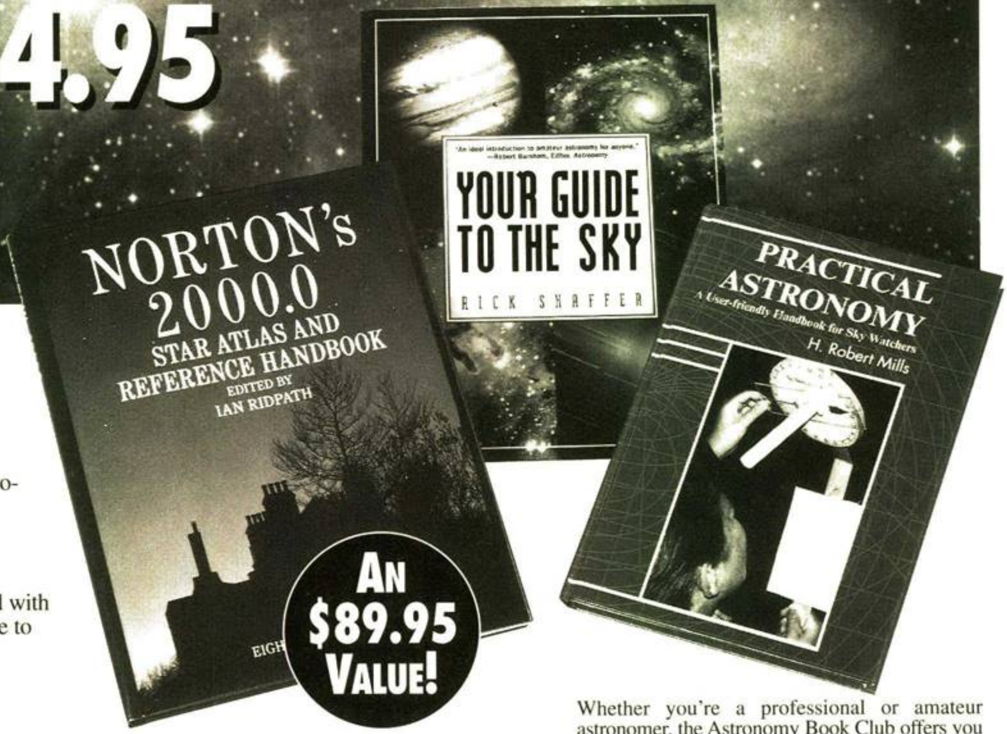
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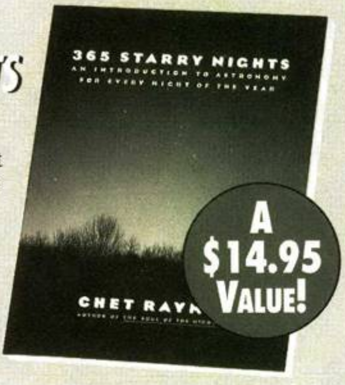

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telescope is trained on Uranus and Neptune, which are optimally placed near the meridian. At 588x Uranus is a lime green dot with pronounced limb darkening, while at 1,176x it is like examining a pea. Despite moonlight, we can see four of the planet's satellites without using averted vision.

The following night, we manage to glimpse subtle markings of very low contrast on the planet. We agree not to share our impressions until we have all committed them to paper; our sketches are virtually identical. The preceding limb is darker than the following limb, while a diffuse arcing streak suggestive of a belt can be seen just to the preceding side of the center of the disk. Three nights later, the northern and southern limbs are each the site of bright, off-white patches, while the "belt" is less pronounced.

Not surprisingly, Neptune doesn't repay repeated scrutiny — a minute, featureless disk, more turquoise in the refractor than the ice blue color I've seen in large reflectors. We can, however, easily follow Triton's orbital motion from night to night.

Saturn, our principal quarry, displays an unusually bland globe streaked with pastel bands of butterscotch yellow tinged with gray and zones that are a creamy off-white.

O'Meara is the first to draw attention to a rather inconspicuous bright spot in the Equatorial Zone, which transits the central meridian early on the morning of Friday, August 11. Announced in an International Astronomical Union circular the following day, the spot isn't seen again for three nights.

When seeing permits a magnification of 1,176x, Titan can be resolved as a very pale disk. Although little more than a pinhead in apparent size, the limb darkening caused by the satellite's extensive atmosphere is quite apparent. I am amazed that the Spanish astronomer Jose Comas Sola was able to discover this aspect of the moon with only 15 inches of aperture in 1908.

On each night prior to the ring-plane crossing, only Sheehan and O'Meara are able, with difficulty, to detect the back-lit ring as an exceedingly faint, sometimes broken thread of light. Later, they describe the extremity of the ring in one ansa (one of the two extreme outer curves of Saturn's rings seen on either side of the disk) as slightly offset from a line connecting Iapetus with the other satellites.

Like the elusive central star in M57, the Ring Nebula, this ghostly feature requires not only a large aperture and a transparent sky, but also a rather tranquil atmosphere.

The actual ring-plane crossing occurs around two in the afternoon of Thursday, August 10 PDT. When we train the telescope on Saturn twelve hours later, the sunlit face of the rings is visible at a glance. During the next three hours the rings brighten dramatically, appearing as prominent without an occulting bar at the end of the observing session as they had at the beginning with one. The ring is a coppery tan, reminiscent of the hue of nylon hosiery. On the following night, the rings have a tapered appearance, like the cross section of a biconvex lens.

In moments of nearly perfect seeing, the shadow of the ring on the globe is a very thin jet black line with crisply defined edges to the limbs of the disk, but when the seeing deteriorates even slightly, the shadow broadens, its edges become diffuse, and a phenomenon analogous to the "black drop" seen during transits of the inferior planets is visible where the shadow line intersects the limbs of the disk.

This subtle effect of minor atmospheric turbulence convincingly explains Percival Lowell's and E. C. Slipher's claim that during the ring-plane passage of 1907 with the 24-inch refractor at Flagstaff they were able to distinguish a "dark medial core" in a shadow band widened by the presumed presence of extra-planar ring particles.

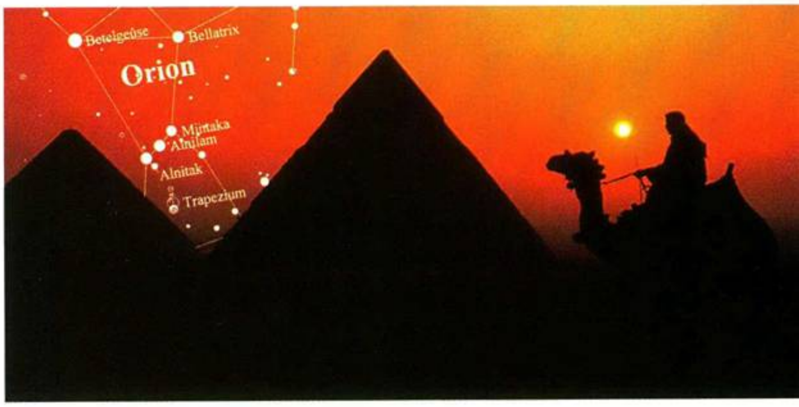
Over a century ago, Princeton astronomer Charles A. Young alleged that for visual planetary observing the relative efficiency of telescopes of varying sizes is not a linear relationship, but is proportional to the square roots of their apertures.

Accustomed to the views provided by a fine 10-inch Newtonian, I can hardly characterize the appearance of the planets through the 36-inch refractor as a revelation, but our results suggest that Young's formula underestimates the performance of large instruments under excellent conditions, which are anything but rare on Mount Hamilton. □

Thomas A. Dobbins is co-author (with Donald C. Parker and Charles F. Capen) of Observing and Photographing the Solar System (Willmann-Bell, 1988).

JACK NEWTON

CCD Astronomy: M27, as located, imaged and processed using TheSky Astronomy Software.



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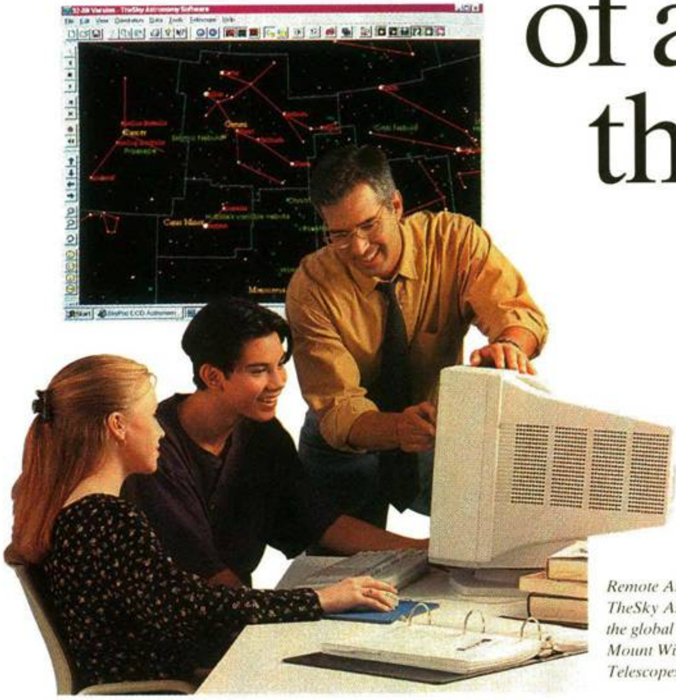

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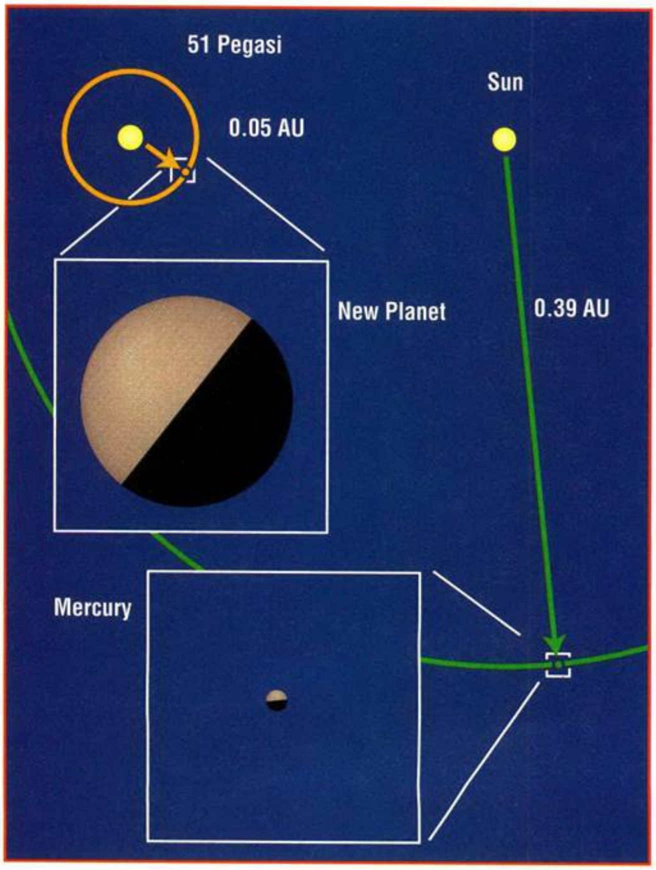
ASTRO NEWS

First Planet Found Orbiting a Solar Twin

Astronomers have searched hundreds of nearby Sun-like stars for planets. So far they have searched in vain. But on October 6, 1995, Michel Mayor of the Geneva Observatory in Switzerland reported the detection of a planet orbiting a star — a star with nearly the same size, mass, and temperature as the Sun.

Mayor told a gathering of scientists in Florence, Italy, that he and colleague Didier Queloz detected a planet with roughly half the mass of Jupiter orbiting the star 51 Pegasi, about 40 light-years from Earth. Surprisingly, the planet whizzes around the star once every 4.2 days, meaning it orbits a mere 7.5 million kilometers from the star, or roughly one-eighth Mercury's distance from the Sun. At that distance, the star's heat bakes the planet's surface to a temperature of 1,000 degrees Celsius, which is probably too hot for life. Despite the heat, the planet could be massive enough to retain an atmosphere of helium, water vapor, methane, and ammonia.

The reported planet is much too faint and close to the star to be observed directly. Mayor and Queloz used a spectrometer with the 1.9-meter telescope at the Haute-Provence Observatory in southeastern France. They detected periodic changes in the star's spectrum indicative of an invisible companion's considerable gravitational influence on the host star. Ten days after the initial report, Geoff Marcy of San Francisco State University and Paul Butler of the University of California at Berkeley independently confirmed the discovery with a more sensitive spectrometer coupled with a 3 m telescope at Lick Observatory.



THE FIRST PLANET seen around a Sun-like star is roughly the size of Saturn, yet orbits more closely than Mercury orbits the Sun.

"There is a very high possibility that the object is a planet, but we still can't be 100 percent sure," said Italian astronomer Roberto Pallavicini, who chaired the Florence conference. Some astronomers caution that the variations in the star's spectrum could be due to intrinsic properties of the star or a companion star in an oblique orbit. But Marcy counters, "The best and straightforward interpretation is that 51 Pegasi is orbited by an unseen companion having about half a Jupiter mass."

Planets have been found orbiting a pulsar (see "Second Chance Planets," page 50), but astronomers were particularly interested in finding planets orbiting stars like the Sun so they could better understand how planets form in a normal environment. But the existence of such a large planet in an orbit so near the parent star raises more questions than it answers about the nature of planetary systems beyond our own. How could such a massive planet form and survive so close to a star? Is our solar system the exception or the norm? What are the implications for the prevalence of life in the Galaxy?

No one yet knows if other planets orbit 51 Pegasi. The 5.5-magnitude star lies at 22h57.5m, 20°46' (2000), almost midway between Alpha (α) and Beta (β) Pegasi and just west of a line that connects the two. Details were sketchy at the time this issue went to press, but more information will appear in future issues of ASTRONOMY.

Hubble Supports Young Universe

New observations from the Hubble Space Telescope add more weight to the argument for a younger, more compact universe. British and American astronomers led by Nial Tanvir of the University of Cambridge measured the distances to Cepheid variable stars in the galaxy M96 in Leo. The absolute brightnesses of these stars are directly related to their periods of pulsation, making them superb distance indicators. Hubble's outstanding resolution allowed Tanvir and associates to record Cepheids in M96, a galaxy more distant than most with previously measured Cepheids.

Tanvir found the distance to M96 to be 38 million light-years. Other studies of

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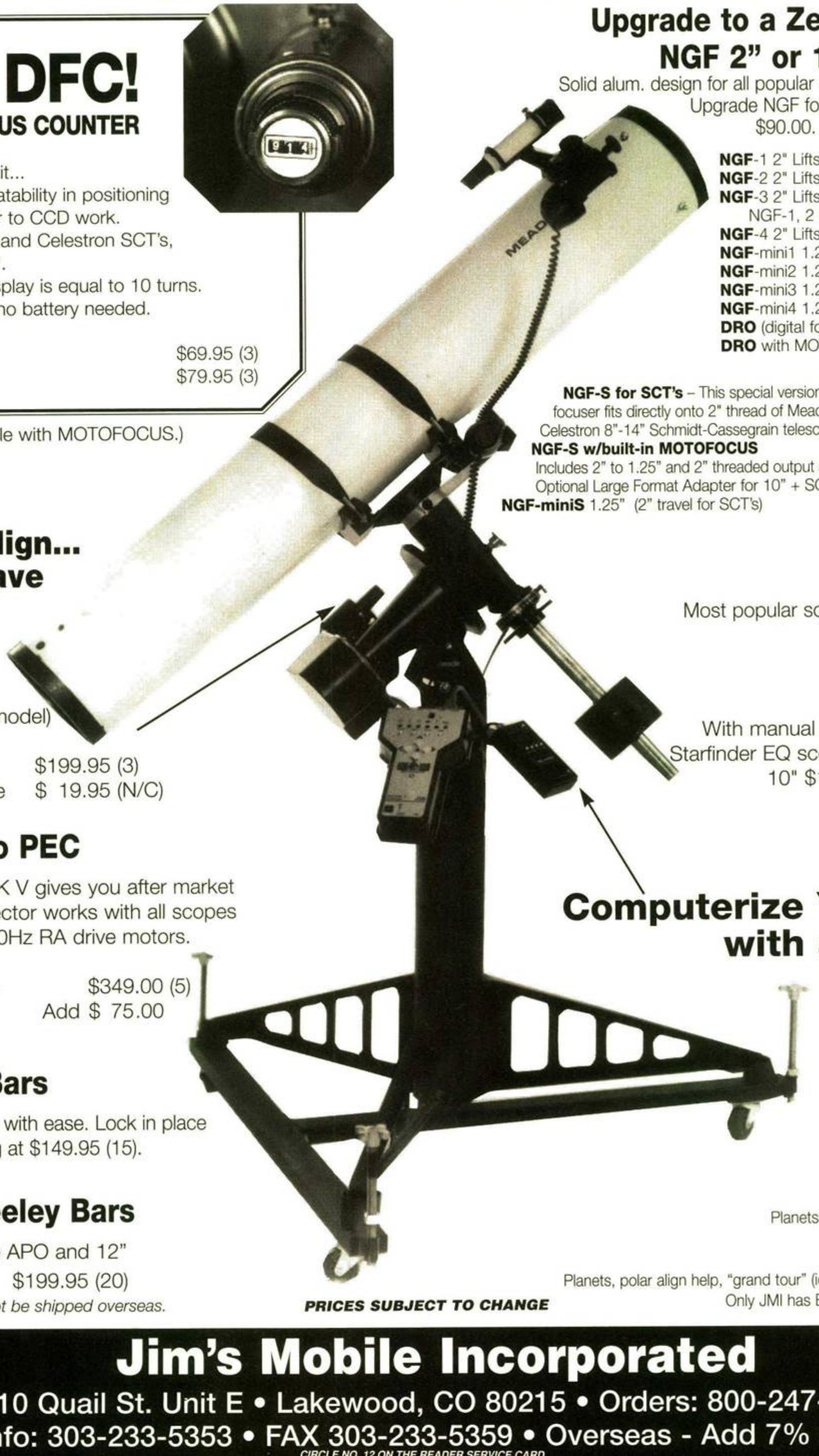

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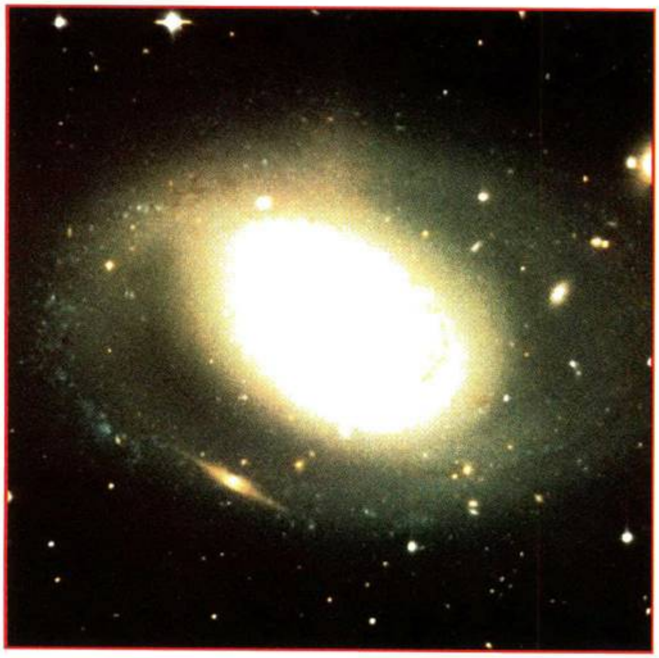
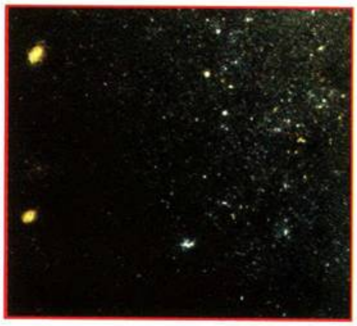


Nial Tanvir, University of Cambridge



Nial Tanvir and NASA

THE LEO GROUP GALAXY M96 has provided astronomers with the latest evidence supporting a relatively young, compact universe. Cepheid variable stars in M96 as seen by Hubble (left) indicate a neighborly distance of 38 million light-years.

the more distant Coma Cluster of galaxies place it nine times more distant than M96. By inference, then, the present study places the Coma Cluster at 340 million light-years away. This permits the astronomers to get a good measurement of the expansion rate of the universe, known as the Hubble constant. They find this rate to be 69 km per second per megaparsec (± 12%). This number is somewhat smaller but in general agreement with earlier Hubble studies of M100 and other galaxies.

Plugging their values into the standard Einstein-de Sitter model of the universe, Tanvir and associates get an age of 9.5 billion years since the Big Bang. Because stellar astronomers claim to have measured stars as old as 15 billion years, this paradox between extragalactic and galactic methods of fixing the universe's age still stands.

Saturn Satellites Come and Go

The 1995 Saturn ring-plane crossings have afforded astronomers the opportunity to add to the list of known satellites. From the May 22 crossing, astronomers using the Hubble Space Telescope discovered four possible satellites (see "New Saturnian Moons," AstroNews, November 1995). From

Harold A. Weaver, P. D. Feldman, and NASA

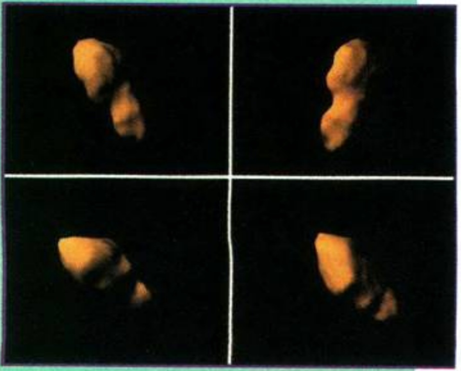
Hubble Sees Hale-Bopp

Images of Comet Hale-Bopp from the Hubble Space Telescope taken October 5, 1995, show a pinwheel-shaped pattern and a blob of cometary debris detached from the nucleus. The blob may be a piece of the comet's crust, cracked loose by sublimation and the comet's rotation. The pinwheel flow of material represents the second time the comet has ejected an arc or wheel-shaped jet of particles. From studying these images and others, astronomers have measured the speed of the debris leaving the comet's nucleus at 109 km per hour.

Comet Hale-Bopp is currently too close to the Sun in our sky to be seen. Next month, however, it will re-emerge in the morning sky. Beginning with the February issue, ASTRONOMY will present detailed, continuous observational coverage of this brightening comet.

TWIST AND TURN. Like a wobbling football, asteroid 4179 Toutatis twists on one axis while spinning around another one. Planetary scientists Scott Hudson of Washington State University and Steven Ostro of the Jet Propulsion Laboratory discovered that the unusual asteroid rotates every 5.4 days around its long axis, while spinning every 7.4 days around its short axis. These periods combine in such a way that Toutatis' orientation with respect to the solar system never repeats. The asteroid measures 1.9 by 2.4 by 4.6 km and has a cratered and strongly two-lobed shape.

Hudson and Ostro made the radar images in December 1992. They hope to map Toutatis in even more detail on September 29, 2004, when the asteroid will flash past Earth at only four times the Moon's distance.



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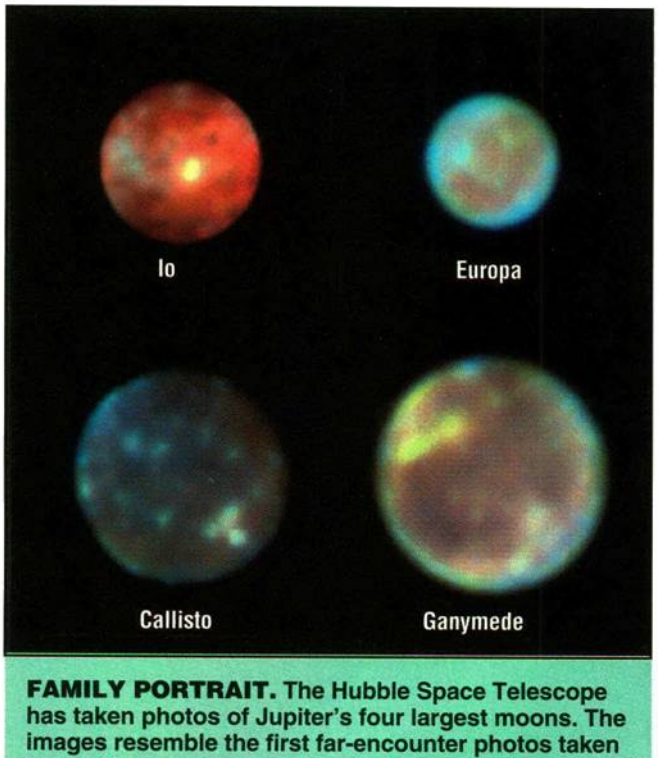
Hubble images of the August 10 crossing, astronomers suspect that two of these satellites are indeed new, and that the other two represent previously known satellites. The Hubble team, led by Phil Nicholson of Cornell University, also spotted another object — roughly 36 km across — that is probably a new satellite, bringing the total number of known or suspected Saturnian moons to 21.

Hubble also spotted two elongated objects in the outer F ring that appear to be arclike clumps in the ring. "If they are clumps, as we suspect, they may well have been created in the 14 years since the Voyager 2 flyby," says Nicholson. The clumps may represent debris from collisions that destroyed small moonlets embedded in the F ring.

Astronomers using the 10 m Keck telescope have discovered a strange phenomenon in Saturn's ring system. The team, led by Imke de Pater of the University of California at Berkeley, found that Saturn's faint E ring, the thickest and outermost ring, is the bluest object in the solar system. This appears to be due to the uniform size of particles in the ring. Because the particles are the same size, they reflect light in a narrow band of blue wavelengths. Saturn's other rings contain particles ranging in size from dust specks to house-sized boulders. Different size objects reflect light across a broad range of wavelengths, making the other rings appear white.



STScI/Lowell Obs./NASA

FAMILY PORTRAIT. The Hubble Space Telescope has taken photos of Jupiter's four largest moons. The images resemble the first far-encounter photos taken by the Voyager spacecraft as it neared Jupiter in the late winter of 1979. HST's ability to monitor the moons from Earth has led to the recent discovery of oxygen on Europa, ozone on Ganymede, and new volcanic activity on Io.

Another Brown Dwarf?

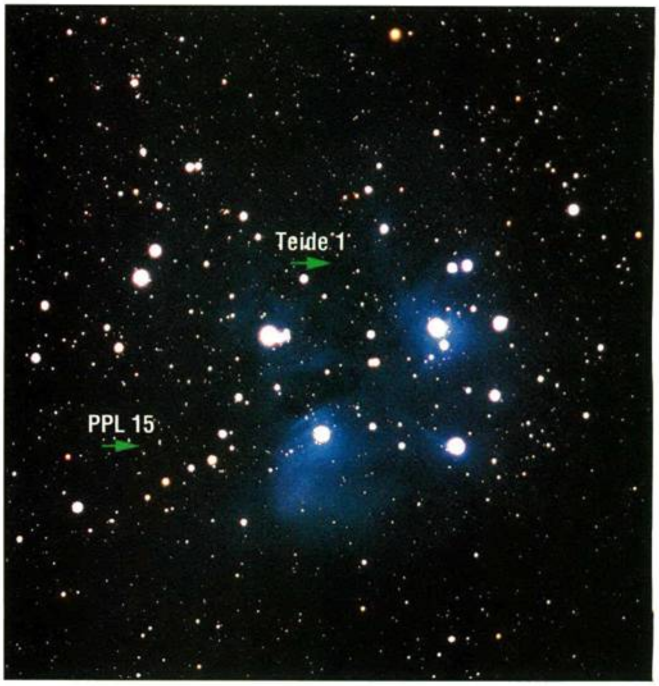
For years astronomers have searched for brown dwarfs, celestial fence-sitters that are more massive than planets but less massive than stars. Brown dwarfs fall below the critical 0.08 solar-mass stellar limit. Objects more massive than this threshold ignite a nuclear furnace, becoming stars. But brown dwarfs don't ignite, they emit radiation from energy left over from their formation.

Astronomers have previously reported a number of brown dwarf candidates, but later they learned the objects were low-mass stars. In June 1995, a team led by astronomers Geoff Marcy of San Francisco State University and Gibor Basri of the University of California at Berkeley reported the discovery of the most convincing brown dwarf candidate yet, a faint object in the Pleiades called PPL 15 (see "Needles in the Cosmic Haystack," September 1995).

In the September 14, 1995, *Nature*, another team, led by Rafael Rebolo of the Astrophysical Institute of the Canaries, reported the discovery of a second Pleiades brown dwarf candidate, Teide 1. Its brightness and apparent surface temperature suggest Teide 1 tips the scales at only 0.02 solar-mass, well below the nuclear ignition threshold. "This object is even fainter than PPL 15, and so should be an even lower mass, that is, a more definitive brown dwarf," says Marcy.

Marcy, Basri, and Rebolo are using the Keck 10-meter telescope to take spectra of both PPL 15 and Teide 1. Over time, heat from a star's nuclear furnace destroys lithium in its atmosphere. So if Marcy and Rebolo find lithium in the spectra, that will show that these objects are not stars, thus nailing down the existence of brown dwarfs.

TWO BROWN DWARFS may inhabit the Pleiades star cluster. Arrows show the location of each brown dwarf candidate.



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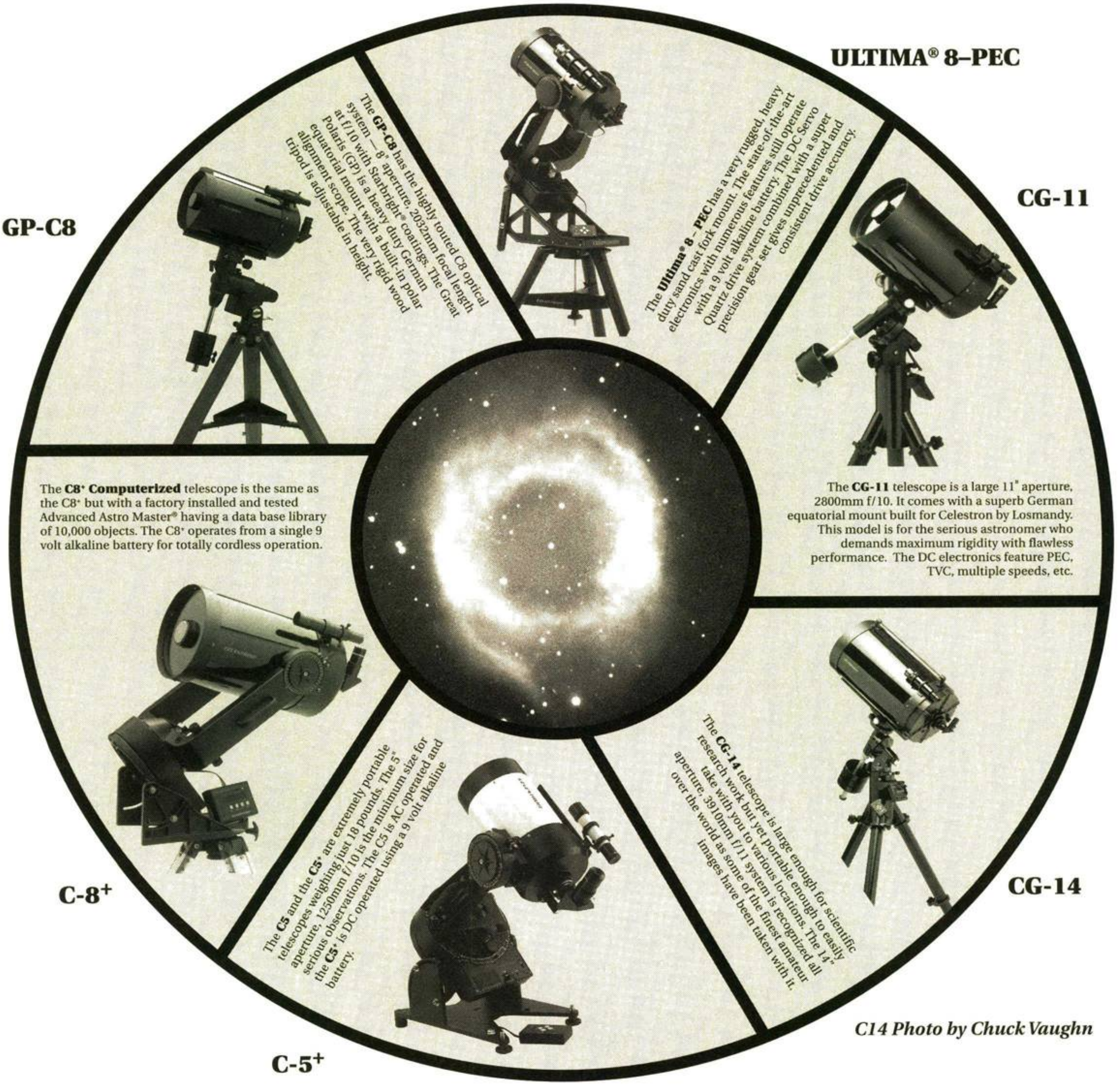

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C14 Photo by Chuck Vaughn

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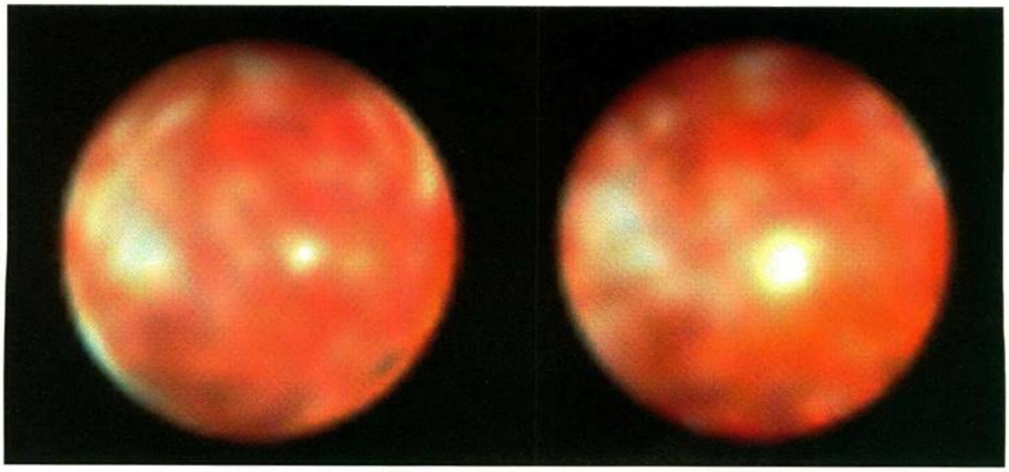
Io Active as Galileo Approaches

Jupiter's volcanically active moon Io erupted with unusual intensity this past summer, with at least six different hot spots observed at one time or other. The fireworks began around July 20, 1995, when Murray Silverstone of UCLA detected a bright spot during infrared observations of the Jovian moon. The eruption apparently came from a prominent but unnamed volcanic caldera seen in Voyager images.

A second hot spot burst forth in mid-August from a region where Voyager saw no prominent caldera. Finally in late August, the volcano named Loki erupted and quickly grew to become the brightest hot spot on Io. Three fainter hot spots also appeared in infrared observations this past summer, as did a bright spot seen in the visible by the Hubble Space Telescope.

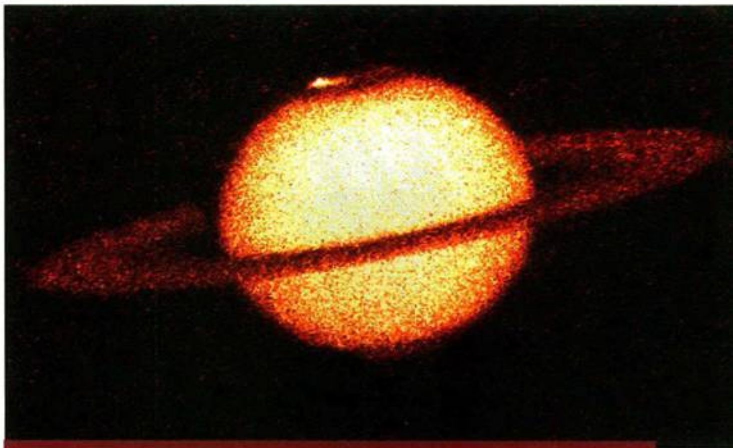
John Spencer of Lowell Observatory, the leader of the satellite discipline of the International Jupiter Watch, said, "The new spot surrounds the volcano Ra Patera and is probably composed of frozen gas ejected from the volcano by a large explosion or fresh lava flows."

Spencer commented that the major changes seen on Io this past summer stand in remarkable contrast to the normal pattern. Typically, Io experiences only minor changes for months at a time, punctuated by occasional rapid changes at one site, usually Loki (see "The Violent Volcanos of Io," May 1993). If it continues, the high level of activity could make for some stunning images when Galileo turns its camera on the moon in the first week of December.



John Spencer (Lowell Observatory), and NASA

MAJOR CHANGES APPEARED ON IO this past July, when the Hubble Space Telescope detected a 200-mile-diameter feature surrounding the volcano Ra Patera (right). The yellowish-white feature, presumably the result of a large eruption, replaced a much smaller whitish spot seen 16 months earlier (left).



John Trauger (JPL) and John Clarke (U. Michigan), the WFPC2 team, and NASA

THE FIRST AURORA EVER SPOTTED on Saturn stands out in this far ultraviolet image taken in October 1994 by the Hubble Space Telescope. The aurora rose 2,000 km above Saturn's cloudtops as it circled the planet's north pole. Astronomers suspected the existence of aurorae on the ringed planet from non-imaging data taken in 1979 by Pioneer 11 and in the 1980s by Voyager 1 and 2, but this is the first image to confirm their suspicion.

Hubble Finds Ozone on Ganymede

Jupiter's largest satellite, Ganymede, appears to be manufacturing ozone in the ices at its surface. The total amount of ozone, a molecule consisting of three oxygen atoms, appears to be only one to ten percent the amount destroyed each year in Antarctica's notorious ozone hole. Keith Noll and his colleagues at the Space Telescope Science Institute discovered the ozone with the Faint Object Spectrograph on the Hubble Space Telescope and announced their finding at the 27th annual meeting of the Division of Planetary Sciences held in Kona, Hawaii, last October.

The ozone on Ganymede arises from charged particles trapped in Jupiter's powerful magnetic field. Jupiter's rapid rotation (it takes less than ten hours to rotate once) sweeps these particles along at tremendous speeds, where they overtake the slower-moving Ganymede and rain down on its icy surface. They then apparently penetrate the surface, disrupting water molecules and producing the ozone.

Although no atmosphere has yet been detected on Ganymede, Noll thinks this oxygen chemistry strongly suggests that the satellite will turn out to have a tenuous oxygen atmosphere. Ganymede would then join its sister satellite, Europa, which Hubble found earlier in 1995 to have a thin oxygen atmosphere.

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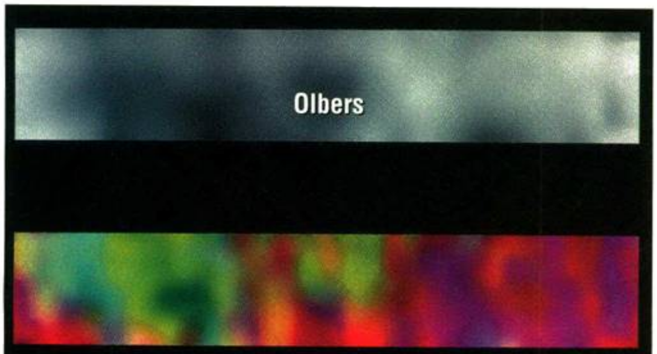
From Sphere to Disk

Using radio telescopes, astronomers have for the first time imaged gaseous material falling toward a newborn star. The scientists, from NASA's Jet Propulsion Laboratory in Pasadena, California, used the 70 m antenna at Goldstone, California, and the Very Large Array at Socorro, New Mexico, to image the 150,000 year-old protostar B335, located 800 light-years away in the constellation Aquila.

The star is embedded in a small gas cloud called a Bok Globule. The astronomers mapped radio emission of the chemical dicarbon monosulfide to trace the motion of the gas as it falls toward the star. The gas forms an infalling spherical envelope around the star. The NASA astronomers believe they are observing this envelope as it collapses into a thin disk. This phenomenon had been predicted, but it had never been seen in such detail. Since astronomers think the Sun's planets formed from a disk of the type forming around B335, team-member William Langer says this study will help astronomers understand how stars and planets originate.

The size of the region mapped by the astronomers is about 7,000 times that of Earth's orbit around the Sun, comparable to the outer solar system where comets originate. Details can be found in the October 1, 1995, *Astrophysical Journal Letters*, or at the following Web site: http:// DSNra.JPL.NASA.gov/~kuiper/.



Georgia Southern Univ./NASA

A COMPLEX LITTLE WORLD. Asteroid 4 Vesta displays a variegated surface as seen in new Hubble Space Telescope maps made by a team of scientists led by Ben Zellner of Georgia Southern University. In the false-color image (bottom), the reddish areas show where impacts have exposed basalt rich in pyroxene, a mineral that crystalizes deep in a planet. The yellow-green region may represent the remains of Vesta's ancient crust. In the black and white map (top), dark areas are probably lava flows, and the feature named Olbers may reveal deep mantle material.

STScI

Giant Space Pancake

The Hubble Space Telescope recently took this image of the dust disk surrounding the young star Beta Pictoris, located about 55 light-years away. Astronomers think the planets in our solar system formed from a disk that resembles this one. The Hubble image shows that the disk is no more than 600 million km thick, which is only about one-fourth as thick as astronomers had previously thought. Such a thin disk increases the likelihood that comet-sized or larger bodies have formed within it.

Gérard de Vaucouleurs, 1918 — 1995

Gérard de Vaucouleurs, the astronomer who discovered that galaxies congregate in superclusters, died in Austin, Texas, on October 7 after a long illness. Passing at 77-years old, he leaves a distinguished career.

A native of France, de Vaucouleurs did original research in virtually every area of astronomy, but was especially interested in galaxies. In 1953, he published a paper suggesting that the Local Group of galaxies belonged to a complex of galaxies he called the local supercluster. Few astronomers put much stock in his suggestion at the time. In 1964, de Vaucouleurs and his wife Antoinette published a catalog providing reliable color and magnitude data for 2,600 galaxies. By the time he, Antoinette de Vaucouleurs, and astronomer Harold Corwin, Jr., issued a revision of the catalog in 1976, containing 4,300 galaxies, other astronomers were beginning to realize that de Vaucouleurs had been right all along.

De Vaucouleurs also played a major role in the current revision of the age of the universe. In the early 1980s, he asserted that the universe was not 15 billion to 20 billion years old, as was accepted at the time, but only 10 billion years old. According to William Jefferys, chairman of the University of Texas astronomy department, "He pioneered the idea that the universe is expanding faster, and is therefore younger than conventional wisdom dictated. This view has gained increasing support in recent years with the advent of newer techniques and instrumentation, such as the Hubble Space Telescope."

In addition to his seminal work on galaxy clustering, de Vaucouleurs introduced a simple formula for calculating the drop-off in the brightness of elliptical galaxies away from their centers. He also revised and refined the galaxy classification system of Edwin Hubble by introducing with the astronomer Allan Sandage a three-dimensional scheme.

"He will be sorely missed as an outspoken voice that was never afraid to champion controversial views," Jefferys says, "views which more often than not have been vindicated with the passage of time."

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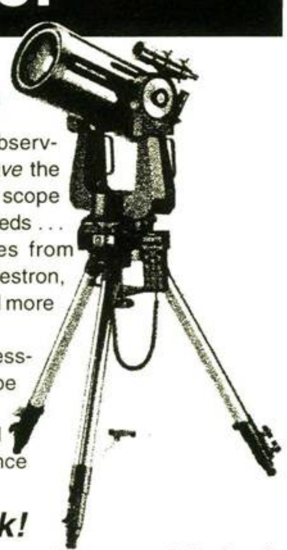

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AstroFest Draws Record Crowds

ASTRONOMY: John Shibley

GROGGY STAR PARTYERS SEEK OUT hidden bargains during one of the largest astro-equipment bazaars east of the Mississippi, the AstroFest Swap Meet. Saturday morning saw traders line a 150-yard path between sleeping cabins and the dining hall. Everything from rare astronomy books to copier machine optics changed hands during the 2½-day Illinois-based star party.

It seems the Midwest's premier star party has yet to peak in popularity. AstroFest '95 drew a record 800-plus people from all over North America for a long weekend of talks, telescope judging, observing, and swap meets. The 16th annual event took place September 15, 16, and 17 at a 4-H camp outside Kankakee, Illinois.

During the day hundreds of amateurs displayed telescopes on Camp Shaw-waw-naw-see's two-acre observing field. One ingenious fellow from Illinois unveiled a custom-modified trailer he uses to haul a 20-inch Dobsonian telescope to a dark observing site. The trailer's fold-out side includes a chart table, power outlets, and a radio. A special compartment inside the trailer keeps his telescope's mirror chilled to night temperatures during transport so it yields steadier images after set-up.

At nightfall the display field came alive as people limbered up their scopes for targets along the summer Milky Way, including still-brightening Comet Hale-Bopp. Since the Last Quarter Moon rose around midnight, evening offered a variety of observing targets for deep-sky and planetary aficionados. Late summer's open clusters and emission nebulae beckoned, followed later by the galaxies of fall. In a separate field behind Shaw-waw-naw-see's dining hall, CCD imagers fired up computers and cameras to land photons far beyond the grasp of even the largest scope on the main observing field.

Day talks featured amateurs and professionals sharing hobby insights. Telescope maker and astrophotographer Dan Joyce gave a primer on video astronomy, while CCD enthusiast Glenn Gombert revealed a technique that discovers near-Earth asteroids. *Sky & Telescope*'s Alan MacRobert presented an inexpensive answer for everyone's undercorrected and overcorrected mirrors, followed by ASTRONOMY's John Shibley, who shared solutions to astrophotography's pitfalls.

For information about this year's AstroFest, scheduled for September 6, 7, and 8, write the Chicago Astronomical Society at P.O. Box 596, Tinley Park, IL 60477-0596. ☐

CNN Taps Atlanta Astro-talent

It's sort of a dream-come-true for the Atlanta Astronomy Club. After years of struggling to get the public turned on to amateur astronomy, along comes CNN and a request for assistance.

Last February a CNN producer sought the AAC's help on a story that profiled different types of telescopes. A special observing session arranged for science reporter Miles O'Brien and his camera crew drew nearly 100 members and guests.

Since then, the successful collaboration has blossomed into a regular segment titled "Backyard Universe," which airs during CNN's "Science & Technology Week" on weekends.

So far, programs have featured interviews with Tim Puckett and Jerry Armstrong, co-discoverers in April 1994 of the M51 supernova, as well as footage of the AAC's Peach State Star Gaze last April. Another program featured observers tracking the Russian space station Mir while it was docked with the space shuttle Atlantis, along with an interview of AAC member Alex Langoussis demonstrating how he uses computer software to plan satellite observing activities.

Science & Technology Week airs every Saturday at 11 a.m. Eastern Time and is repeated Sunday at 4 p.m. Eastern Time. Check your local listings for broadcast times in your area, or call up the AAC's Internet home page at http://www.mindspring.com/~aleko/atlastro.html for word on upcoming broadcasts. CNN's home page is accessible at http://www.cnn.com/. — *Ken Poshedly*

Ken Poshedly

CNN DESCENDS ON A STAR PARTY during a recent filming for the program Science & Technology Week. The Atlanta Astronomy Club works with CNN to produce a periodic segment on backyard astronomy. Science correspondent Miles O'Brien (with a portable video camera) pauses between takes to get some pictures of his own.

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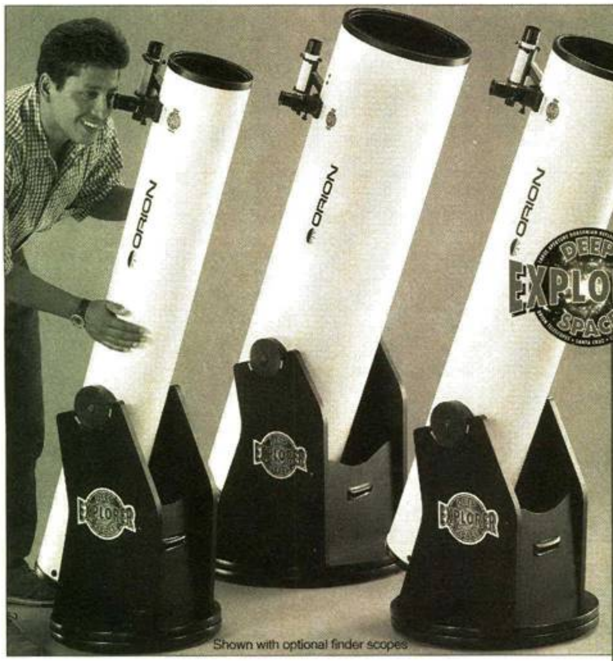

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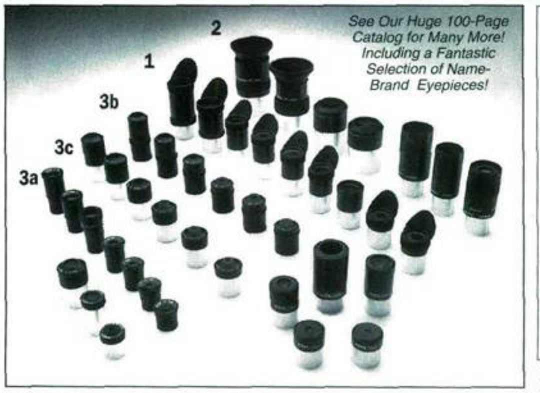

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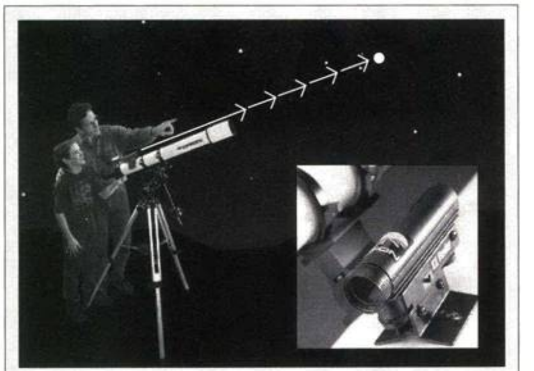

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for SC	#5116	**$26.95** (2.98)
for C-90	#7115	**$34.95** (2.98)

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.965" Diagonal #8791 **$44.95** (3.45)

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Orion's multi-coated diagonals are ideal for refractors and Schmidt-Cassegrains.

1.25" Star Diagonal	#8763	**$49.95** (2.98)
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For Schmidt-Cass. #8771 **$219** (4.71)

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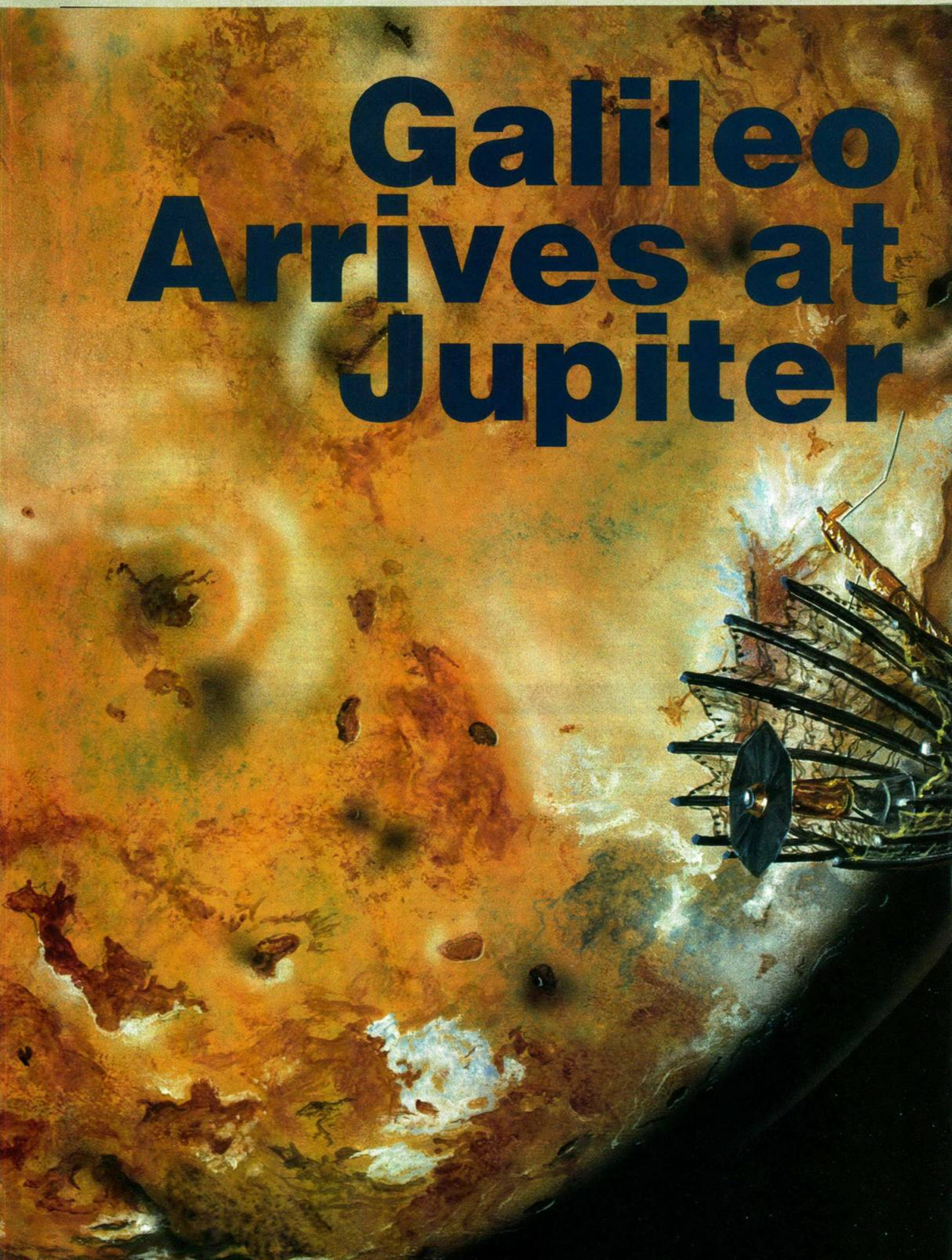
Galileo Arrives at Jupiter

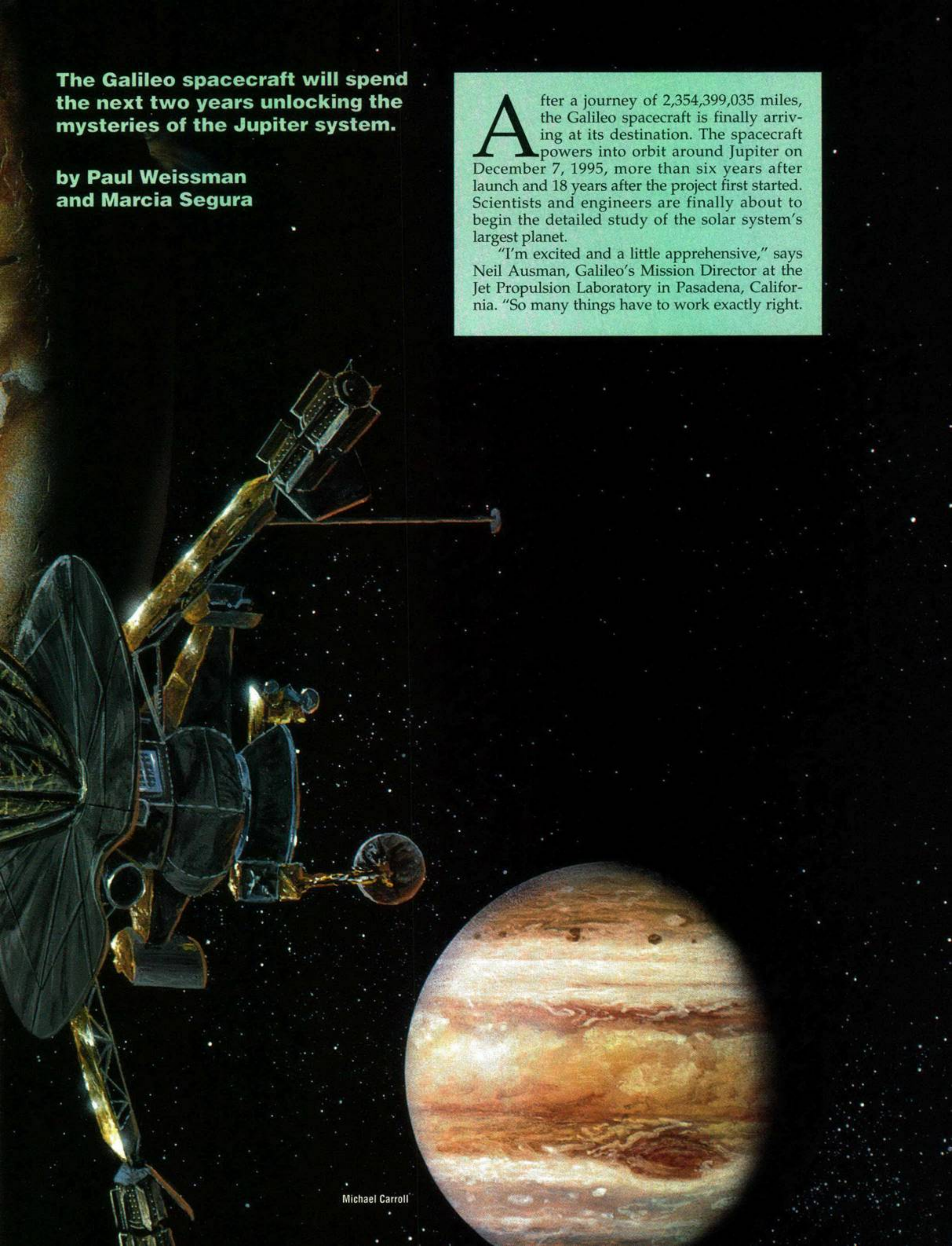


The Galileo spacecraft will spend the next two years unlocking the mysteries of the Jupiter system.

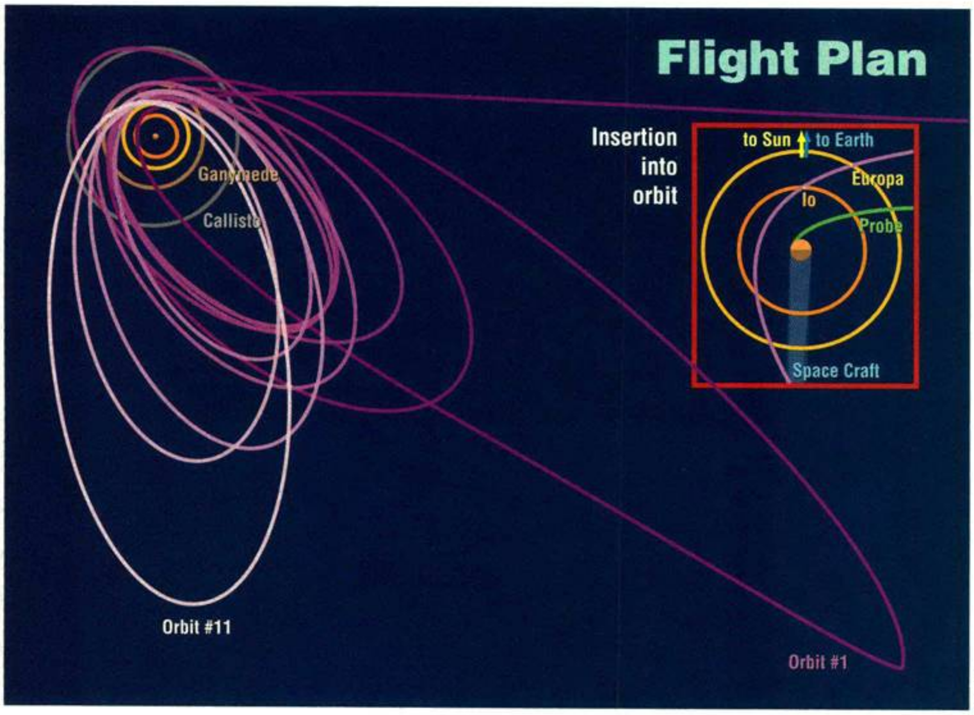
by Paul Weissman and Marcia Segura

After a journey of 2,354,399,035 miles, the Galileo spacecraft is finally arriving at its destination. The spacecraft powers into orbit around Jupiter on December 7, 1995, more than six years after launch and 18 years after the project first started. Scientists and engineers are finally about to begin the detailed study of the solar system's largest planet.

"I'm excited and a little apprehensive," says Neil Ausman, Galileo's Mission Director at the Jet Propulsion Laboratory in Pasadena, California. "So many things have to work exactly right.



Michael Carroll



RUNNING CIRCLES around Jupiter. Galileo will orbit the giant planet 11 times before fuel runs out. Inset: Galileo's initial approach on December 7, 1995.

NASA

It's the most demanding planetary mission we have ever launched."

Ausman has been with Galileo since the mission received Congressional approval in September 1977. That was only a few weeks after NASA launched the twin Voyager 1 and 2 spacecraft on their Grand Tour of the outer planets. Galileo was NASA's first planned follow-on mission. It would orbit Jupiter and study the planet, its satellites, and its intense magnetosphere in detail over two years. Most important, Galileo would drop the first scientific probe into Jupiter's atmosphere. While descending by parachute the probe would make critical measurements of the composition and structure of the Jovian atmosphere.

The Jovian System

With four large satellites, at least 12 smaller ones, a ring, and a magnetosphere 1,200 times larger than Earth's, the Jovian system is almost a mini-solar system in its own right. The planet itself could hold more than 1,000 Earths. Its atmosphere boasts immense storm systems, one of which, the Great Red Spot, is more than twice Earth's diameter and has persisted for at least 300 years. Counterflowing winds traveling up to 375 miles per hour create colorful bands in the atmosphere.

The four large Galilean satellites — Io, Europa, Ganymede, and Callisto — are fascinating worlds themselves. Tidal heating by Jupiter drives active volcanos on Io. Europa's cracked icy surface may have an ocean of liquid water beneath it. Ganymede, the largest satellite in the solar system (it is larger than Mercury and Pluto), is crisscrossed by strange grooved terrain indicative of tremendous tectonic stresses. Callisto, the outermost Galilean satellite, is the most heavily cratered body in the solar system.

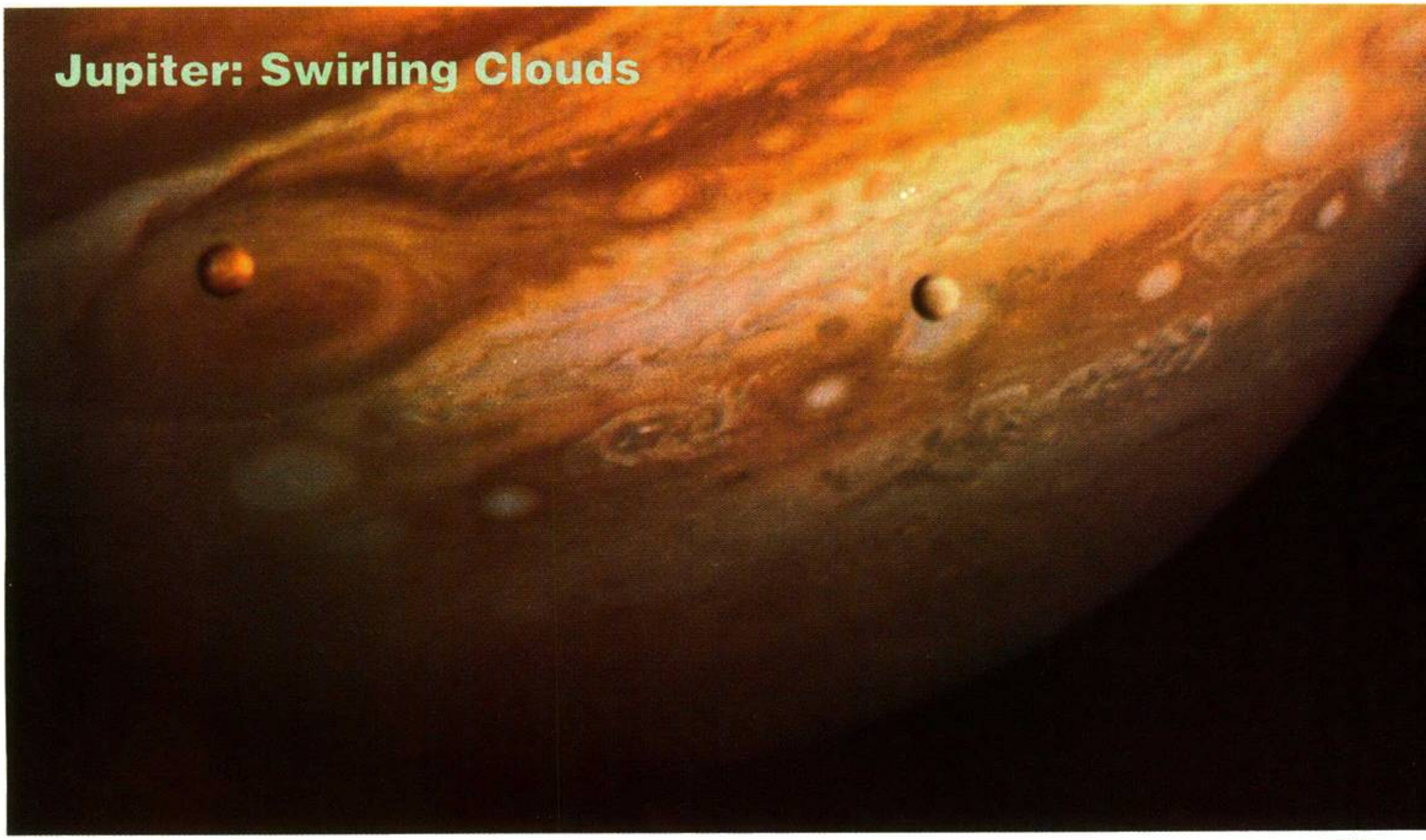
The Pioneer and Voyager flyby missions increased scientific knowledge of the Jovian system by leaps and bounds. But the missions also prompted many new questions. For example, what is the vertical structure and composition of the clouds in Jupiter's atmosphere, and what drives the complex wind system? What causes the volcanos on Io to turn on and off? Are there similar hot spots on Europa? What is the surface composition of each Galilean satellite? What is the nature of the material in the Jovian ring, and where does it come from? Are there long-term variations in the Jovian magnetosphere?

Galileo will come between 20 and 100 times closer than Voyagers 1 and 2 to each of the Galilean satellites. As a result, imagers and spectrometers onboard Galileo will see far more detail on their surfaces. Galileo uses a CCD camera, as compared to Voyager's vidicon camera, an older and less accurate technology. Galileo also carries a near-infrared mapping spectrometer, an instrument that was not even possible with the early 1970s technology carried by Voyager. In addition, Galileo's two-year mission allows it to look for temporal changes in the system, and to perform follow up observations on early discoveries. The mission will almost certainly uncover many new mysteries, posing questions for a future generation of scientists and spacecraft to answer.

The Perils of Galileo

Galileo was originally to be launched by the Space Shuttle in 1982. But the spacecraft remained stuck on the ground because of repeated delays in development of both the Shuttle and the upper stage that was to rocket Galileo out of Earth orbit. The Challenger disaster in January 1986 delayed Galileo an additional three years. NASA canceled the Centaur rocket, which would have allowed Galileo to reach Jupiter on a direct trajectory in about 2½ years. Galileo was forced to use a complex 6-year Venus-Earth-Earth gravity-assist trajectory to build up enough energy to reach Jupiter. But finally, on October 18, 1989, the shuttle Atlantis launched the 5.3-meter-tall, 1,291-kg Galileo orbiter (and its 1,089 kg of fuel) and the 338-kg probe into orbit. A few hours later Galileo's solid rocket booster fired, sending the spacecraft on its way to Venus.

The Venus encounter in February 1990 retargeted Galileo for an Earth flyby in December 1990. Earth flung Galileo beyond the orbit of Mars, where it made the first close flyby of an asteroid, 951 Gaspra, in October 1991. A second Earth encounter in December 1992 gave Galileo the right orbital velocity and timing to go to Jupiter. On its way the spacecraft encountered a second asteroid, 243 Ida, in August 1993. Surprisingly, Galileo found a small satellite, Dactyl, in orbit around Ida — it was the first confirmed satellite discovered



NASA

THE KING AND HIS COURT. Voyager 1 took this snapshot of Jupiter, Io, and Europa during its brief 1979 flyby. Galileo will hang around for two years.

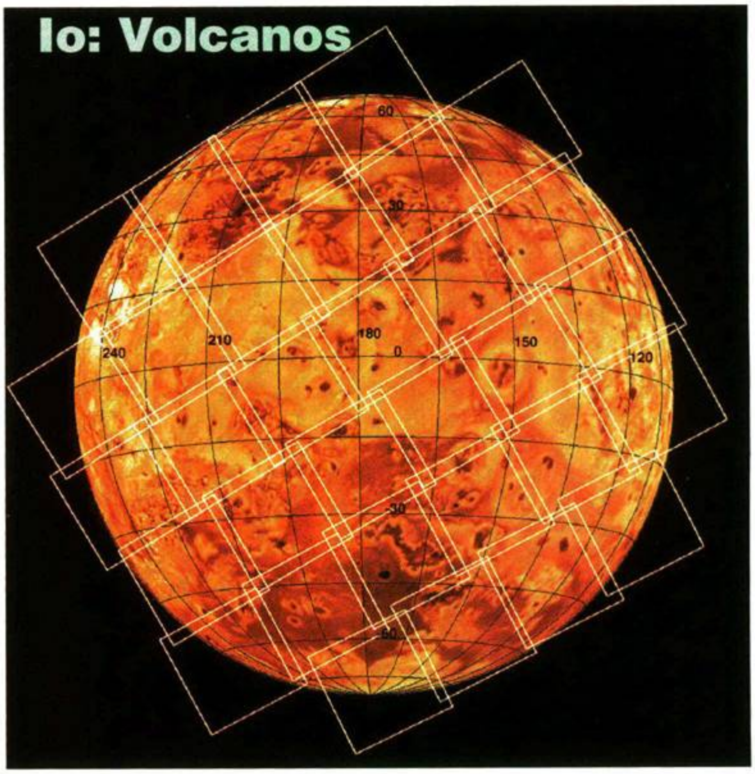
orbiting an asteroid.

But all was not well with Galileo. The spacecraft used a deployable, 4.8-meter diameter high-gain antenna, designed to open like a giant umbrella. Because of increased solar heating at Venus' orbit, JPL's engineers planned to keep the antenna furled until after the first Earth encounter. But when they tried to open the antenna in April 1991, it stuck. Three of the antenna's 16 ribs did not release correctly, and all attempts to cure the problem have failed. How could Galileo transmit data from Jupiter — over a range of 400 to 600 million miles — without its high-gain antenna?

"I couldn't believe it when the antenna didn't open," says Ausman. "I did not anticipate that failure mode. But I thought, 'we'll fix it anyway.' Then when I finally concluded we weren't going to do it, I saw that we could still have a good mission with the low-gain antenna. Through it all, I never had time to sulk. We had too much work to do."

A Trickle of Data

Project scientists and engineers devised ingenious procedures for getting the most out of Galileo's tiny low-gain antenna. Because of Galileo's elliptical orbit around Jupiter, the most intense science activity occurs during a 7-day period within each orbit, centered around closest approach to Jupiter. These periods include at least one close satellite encounter,



NASA

MISSED OPPORTUNITY. Galileo was scheduled to take high-resolution images of Io during its initial pass through the Jupiter system on December 7. Each square in this false-color depiction represents a planned image.The broken tape recorder has nixed this plan.

coming as close as 200 km, and often an additional more distant encounter between 20,000 and 100,000 km from a second satellite.

The rush of data during each of the 7-day encounters will completely fill Galileo's tape recorder, which can only hold about 900 megabytes of data, about one-quarter as much data as the hard disk on a modern personal computer. Scientists have programmed Galileo to slowly play the data back during the one- to two-month orbital cruise period prior to the next close approach to Jupiter.

Before the high-gain antenna failed, Galileo's engineers had planned to transmit data at rates up to 134,000 bits per second (a single picture contains about 5 million bits). Using Galileo's low-gain antenna, receiving stations on Earth could only detect 10 bits per second from the spacecraft at Jupiter. Engineers from JPL's Deep Space Network improved this rate significantly by installing new receivers and feed horns on ground stations. These modifications lowered the background noise and allow communication with Galileo at rates up to 160 bits per second.

Galileo engineers also developed new ways to compress the data being transmitted by the spacecraft, using complex mathematical codes to send the same information with fewer bits. To reduce the data volume, each of the 11 scientific instruments will edit its own data before putting it on the tape recorder. The data will then be played from the tape recorder into the central computer's memory, where it will be further edited and compressed with new algorithms written by Galileo engineers and scientists. Only the information most essential to the scientific goals of the mission will be preserved and transmitted to Earth.

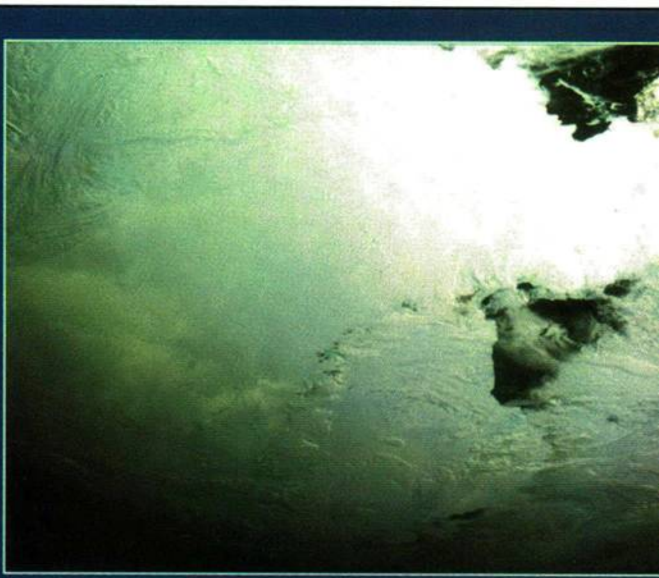
Remarkably, these and many other fixes were accomplished with a sharply reduced budget and a reduced staff. NASA belt-tightening resulted in a 30 percent cut in Galileo's operating budget. The smaller flight team and heavier work loads have tired out many people, and tempers have often flared at meetings called to iron out problems. For many of the scientists who have already devoted more than 18 years to the project, the promise of reduced data sets has been a big disappointment.

Still, a unique spirit drives the Galileo staff. "I'm amazed at the resiliency of our people," says Ausman. "When things go wrong, they won't go home. You have to throw them out of here. Even in the most trying periods, commitment to success drives them."

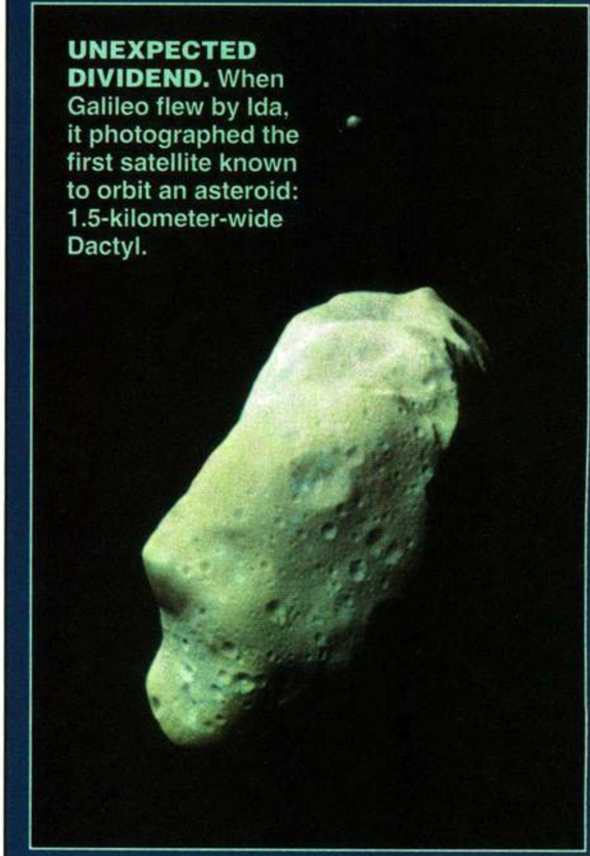
Probing the Atmosphere

In a sense, Galileo's Jupiter encounter has already begun. On July 13 Galileo released the atmospheric entry probe, precisely orienting it for its fiery plunge into Jupiter's equatorial zone on December 7. Two weeks later, on July 27, Galileo's main engine fired to target the spacecraft for its orbit insertion maneuver, also on December 7.

Galileo's first day at Jupiter is its busiest. At 8:08 a.m. EST Galileo encounters Europa at a distance of 32,450 km, about eight times closer than either Voyager came to that satellite. At 2:45 p.m. EST it passes a scant 1,000 km above the active volcanos on Io's sur-

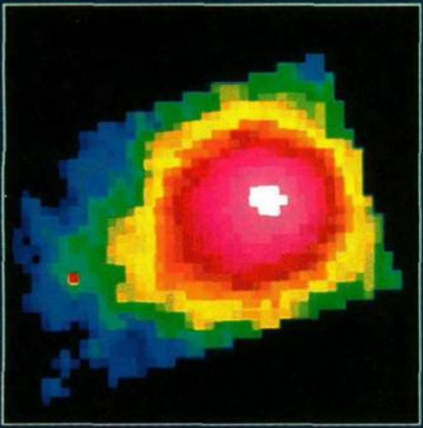


JUST PASSING THROUGH. . . Galileo's first Earth encounter in December 1990 produced this stunning view of Antarctica.



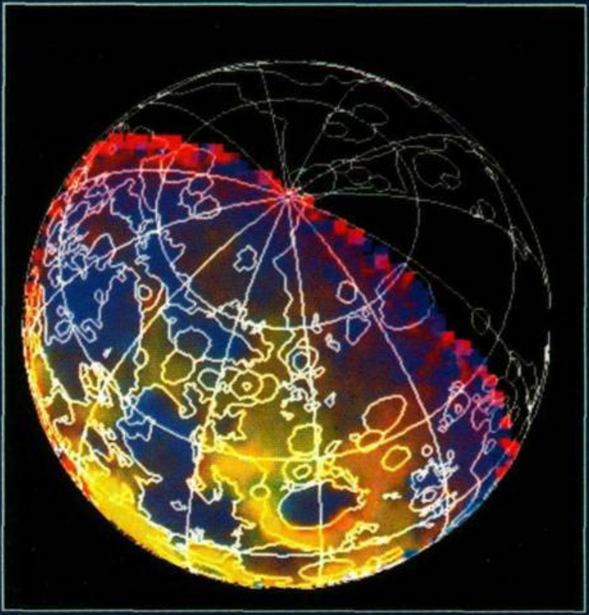
UNEXPECTED DIVIDEND. When Galileo flew by Ida, it photographed the first satellite known to orbit an asteroid: 1.5-kilometer-wide Dactyl.

Galileo's Excellent Adventure



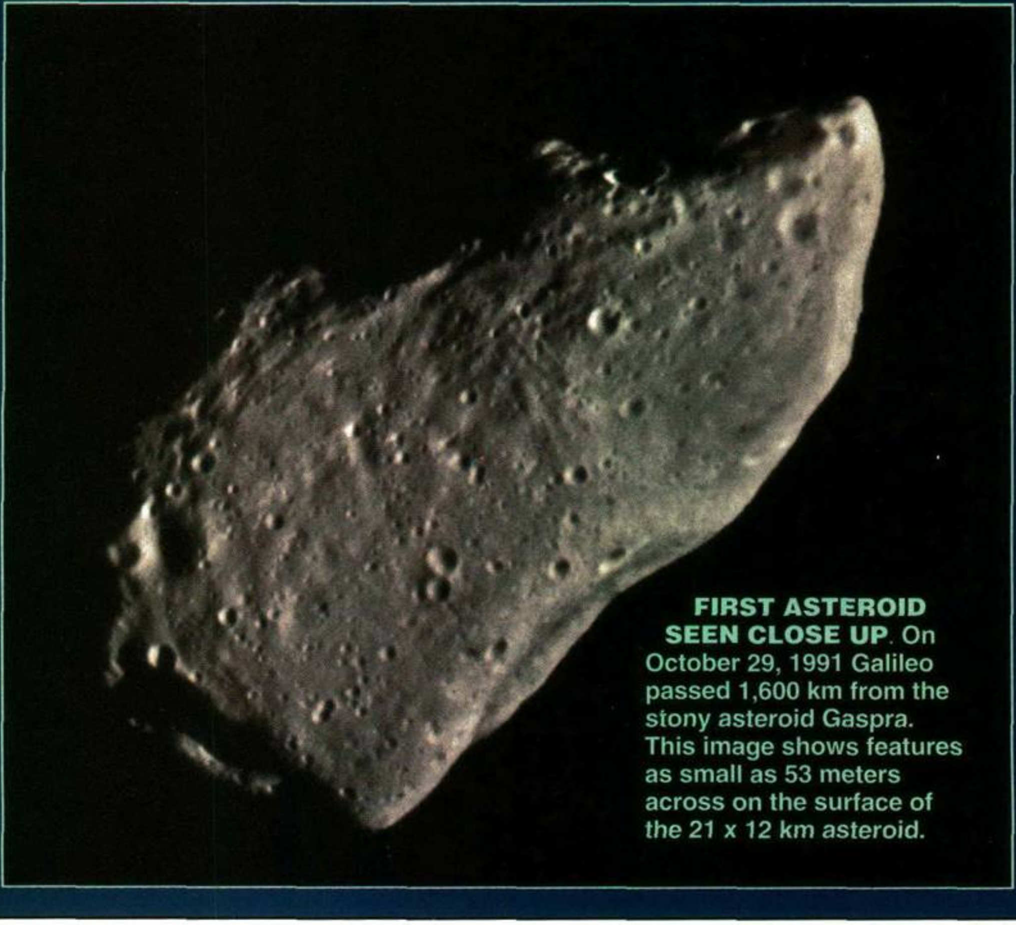
EARTH'S HALO stands out in this false-color image taken by Galileo's ultraviolet spectrometer during the second Earth encounter in December 1992. The halo comes from water molecules in the Earth's upper atmosphere that have been broken up by sunlight. The Moon is the small, dark dot at the left, immersed in the halo.

BLUE MOON. Galileo's Near Infrared Mapping Spectrometer (NIMS) provided this image of the Moon's north pole. The blue areas indicate regions rich in the volcanic minerals olivine and pyroxene. The contour lines show high concentrations of these minerals in the lunar maria.



A PEEK THROUGH THE CLOUDS. In February 1990 NIMS peered through the upper clouds of Venus to produce this spectacular image of the middle cloud deck on the planet's night side.

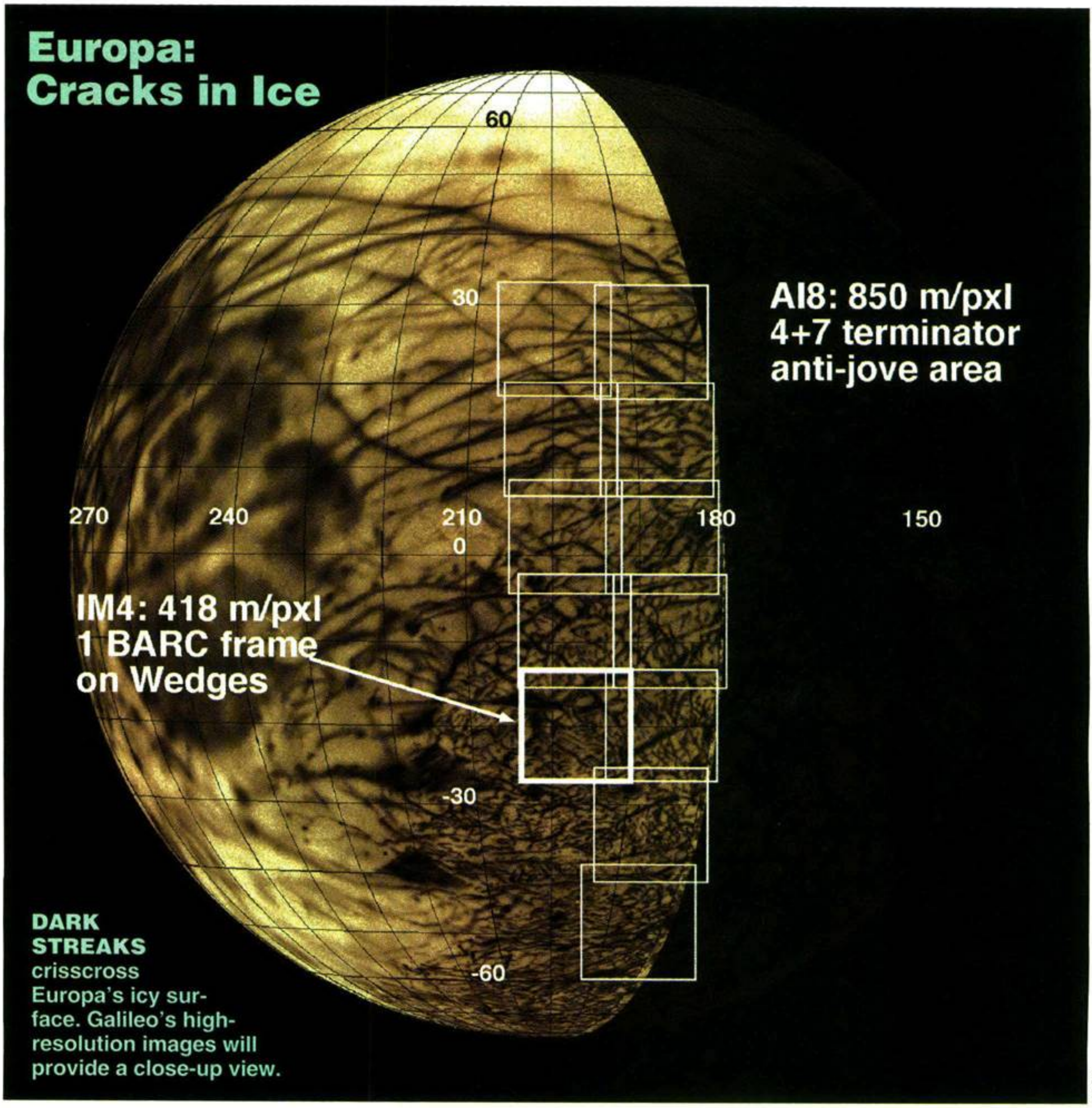
BANG! Galileo was in just the right position to observe the fragments of Comet Shoemaker-Levy 9 slam into the night side of Jupiter in July 1994. These images of the last impact, fragment W, were taken 2⅓ seconds apart. They show the meteor-like flash as the fragment blasted into the atmosphere at 60 km per second.



FIRST ASTEROID SEEN CLOSE UP. On October 29, 1991 Galileo passed 1,600 km from the stony asteroid Gaspra. This image shows features as small as 53 meters across on the surface of the 21 x 12 km asteroid.

All images from NASA

Europa: Cracks in Ice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IM4: 418 m/pxl
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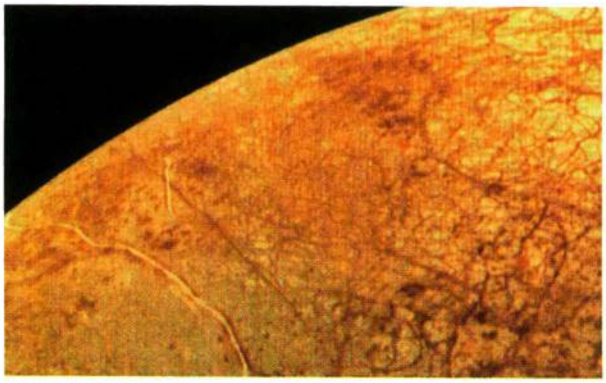
DARK STREAKS crisscross Europa's icy surface. Galileo's high-resolution images will provide a close-up view.

NASA

Surpassing Voyager



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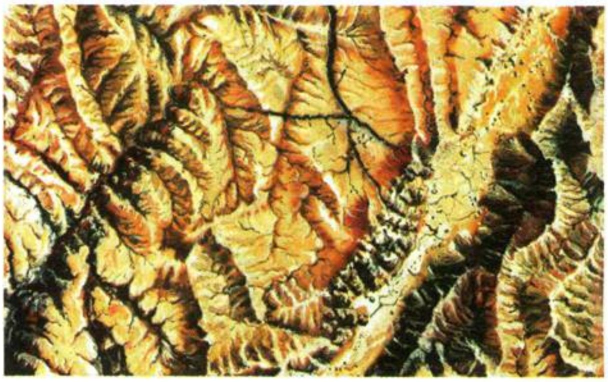
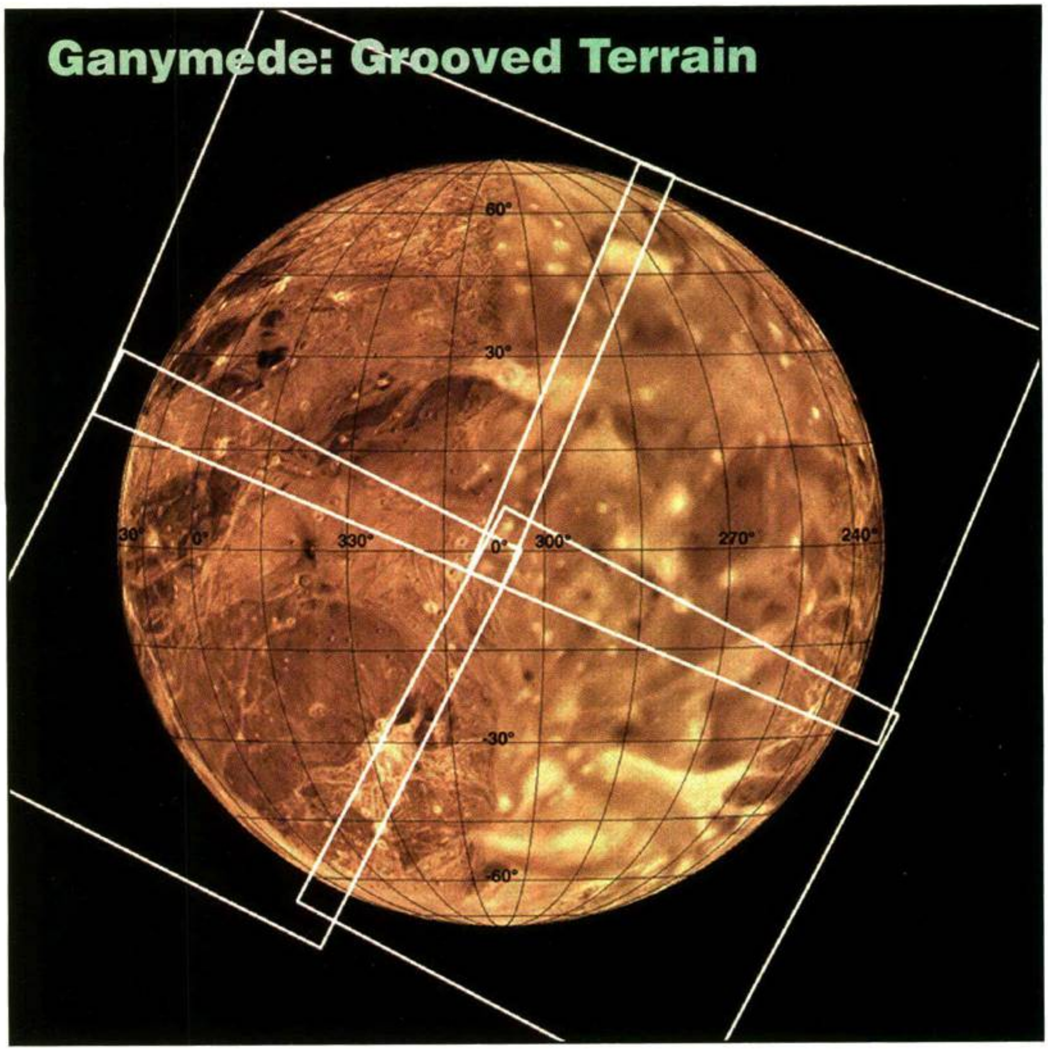


NASA

VOYAGER captured this view of Europa from a distance of 240,000 km, close enough to see features only 5 km across.

WILL EUROPA LOOK LIKE THIS? This hypothetical image shows what Galileo might be able to see: objects 11 meters across, as small as a house.

THE LARGEST SATELLITE in the solar system will receive special attention. Galileo will help scientists understand the grooved terrain, long ridges that stretch across large areas of the surface.



NASA

face. Galileo will observe Europa, although a malfunctioning tape recorder will prevent observations of Io and the atmospheric probe's entry site.

About 4½ hours after the Io flyby, Galileo makes its closest approach to Jupiter, 216,452 km above the Jovian cloud tops (about 3 Jupiter radii). Ten minutes later, the atmospheric probe begins its plunge into Jupiter's atmosphere, 6.6 degrees north of the equator, at a velocity of 47.4 km per second (106,000 mph). Friction from the entry burns off two-third's of the probe's heat shield. In less than 2 minutes the probe slows to 0.8 km per second, still about 20 km above the Jovian clouds. An explosive charge deploys a parachute, which seconds later pulls the capsule away from the heat shield. The capsule and parachute slowly descend through the atmosphere.

As it descends the probe measures the atmospheric temperature, pressure, density, and composition, as well as the size of cloud particles and the net sunlight penetrating the clouds. It also looks for evidence of lightning. The probe's five scientific instruments begin transmitting data back to the Galileo orbiter overhead. Some of the data is stored in the computer memory because of the tape recorder malfunction. The orbiter continues to listen for probe data for 75 minutes, during which time the probe descends to a pressure depth of at least 20 bars (the atmospheric pressure at the Earth's surface is about 1 bar), about 160 km below the top of the Jovian cloud deck.

The probe's mission may end sometime before the 75 minutes are up. The increasing atmospheric pressure may crush the structure holding the instruments, while the rising temperature will likely burn out the electronics. The probe's battery will be running low on electrical power. But by that time the probe will have done its job, and its treasure trove of data will be safely stored onboard the orbiter.

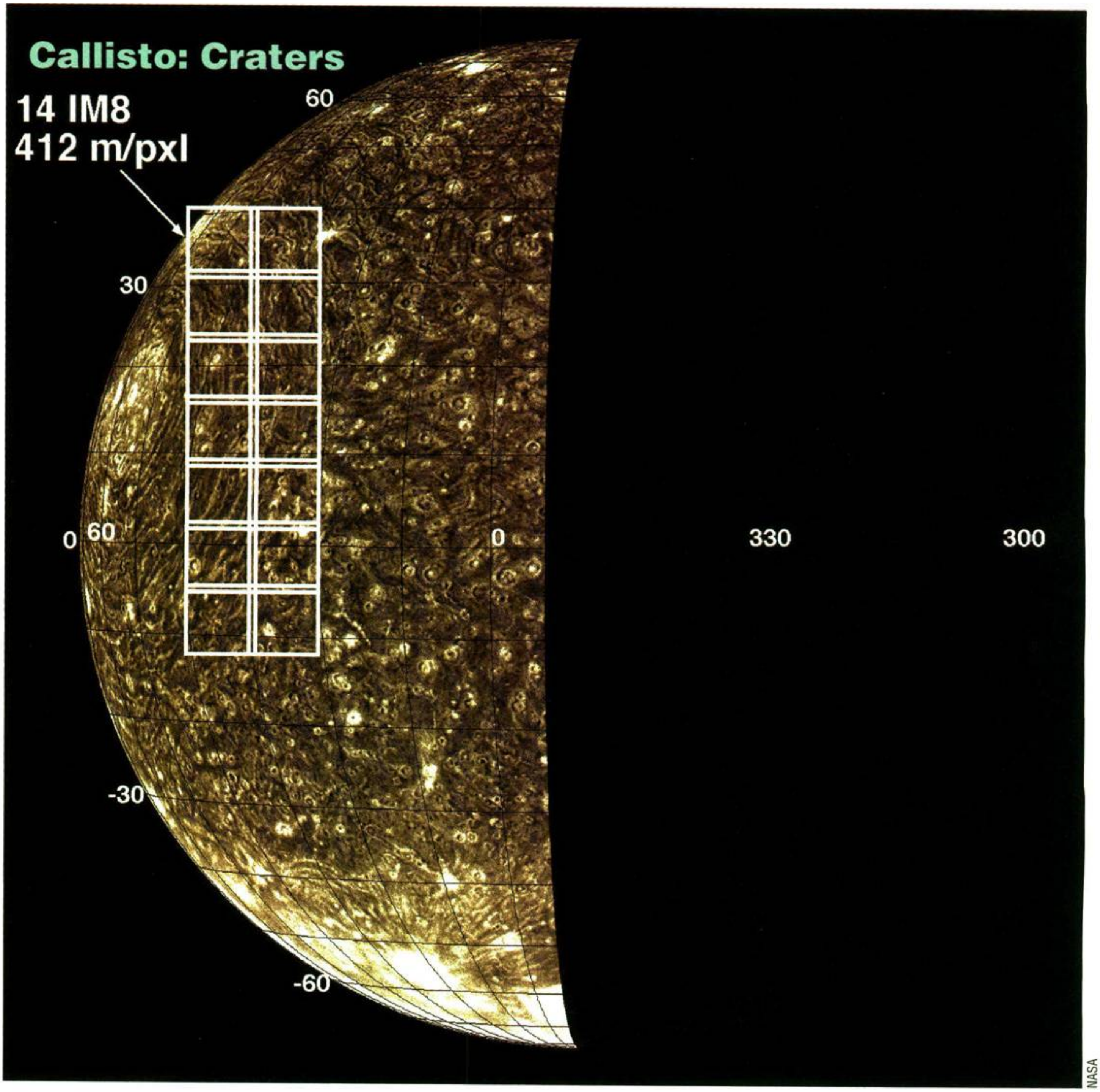
Flying Loops Around Jupiter

After the probe relay ends, Galileo's next order of business is to rapidly reconfigure itself for the critical orbit insertion burn. Beginning at 7:27 p.m. EST, a 47-minute firing of the main engine slows the spacecraft just enough to be captured into a large, looping orbit around Jupiter. Special fault-protection software aboard the spacecraft guarantees that the probe data relay and burn occur, even if there are multiple failures on the spacecraft.

Galileo's final job on that busy day is to perform an occultation experiment as it passes behind Jupiter as viewed from the Earth. The orbiter's radio signal fades out as it is refracted by Jupiter's atmosphere, and then it fades back in as the spacecraft reappears on the other side of the giant planet. This experiment serves as a backup to the probe measurements and helps determine the structure of Jupiter's atmosphere at other locations on the planet.

Galileo's first orbit around Jupiter is the longest. It takes 209 days, and it is used to slowly transmit the atmospheric probe data as well as the Europa observations made during the initial close approach. The spacecraft also transmits continuous measurements of Jupiter's magnetic field and charged-particle environment. At its farthest point from Jupiter, about 275 Jupiter radii (19.7 million km, or about 0.13 AU), the main engine fires once again to target the orbiter for its next satellite encounter, with Ganymede, on July 4, 1996.

Galileo soars by Ganymede at an altitude of only 500 km, over 100 times closer than either Voyager



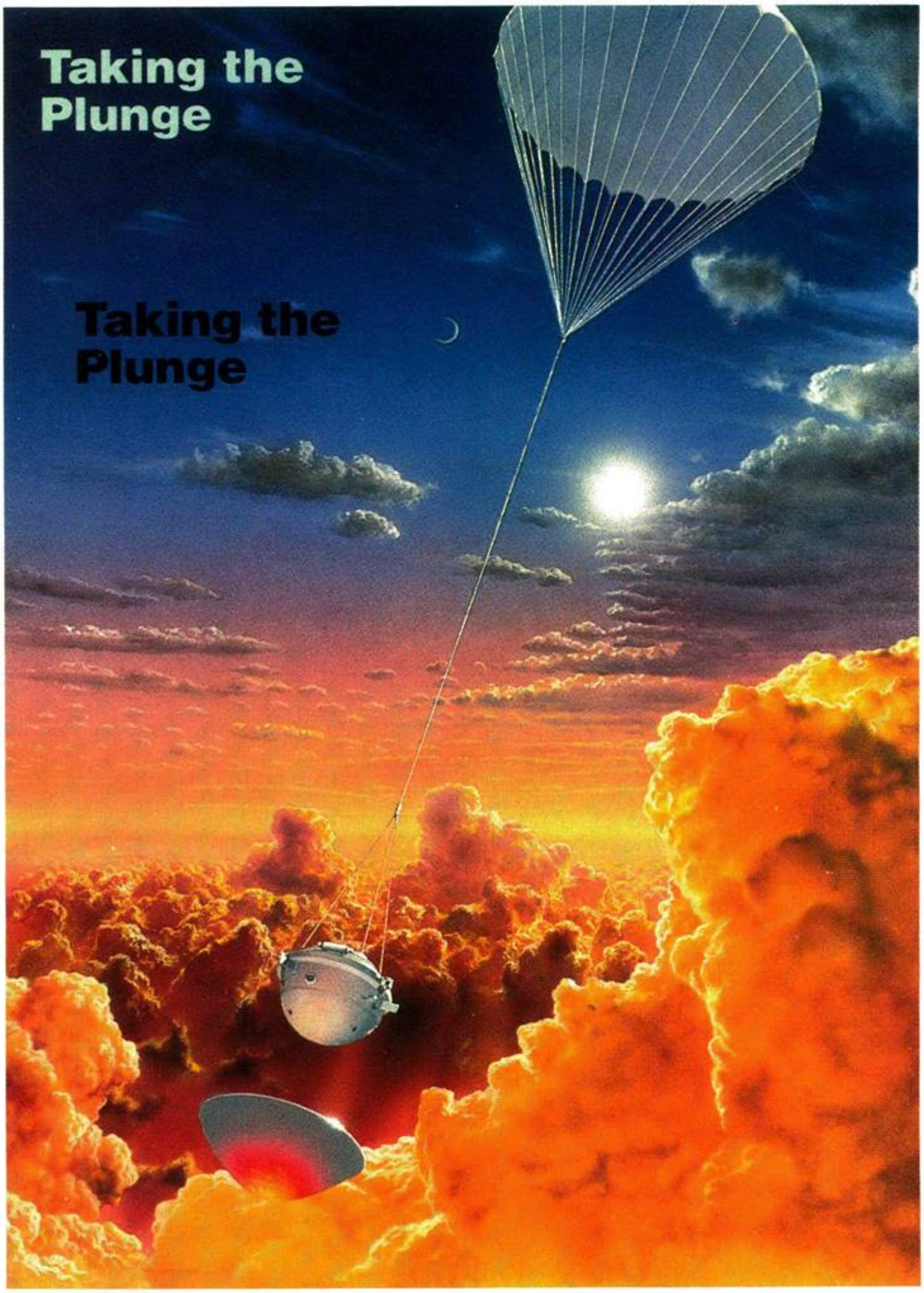
NASA

BATTERED AND BLUDGEONED Callisto is the most heavily cratered body in the solar system.

spacecraft came to that satellite. In addition to scientific observations, the flyby gravitationally "pumps" Galileo to a much shorter orbital period, reducing it from 209 to 64 days. A second Ganymede encounter on September 6, 1996, at a yet lower altitude of 200 km, "cranks" the plane of Galileo's orbit to match that of the Galilean satellites, allowing the spacecraft to make its first encounter with Callisto on November 4, 1996, at a distance of 1,232 km.

Once in the plane of the satellite orbits, Galileo repeatedly visits Europa, Ganymede, and Callisto over the next year. Galileo can't go back to Io because a second pass through the intense radiation belts that close to Jupiter would burn out the spacecraft electronics. In all, JPL plans for Galileo to make 11 orbits around Jupiter, with close satellite encounters on 10 of them. The fifth orbit occurs when Galileo is too close to the Sun (as viewed from the Earth) for reliable commands and data to be transmitted. The tenth orbit carries Galileo 140 Jupiter radii (10 million km) down the tail of Jupiter's magnetosphere, where it will make vital measurements of the magnetic field and charged-particle environment.

The nominal Galileo mission ends with a Europa flyby on November 6, 1997. At that point engineers expect the fuel needed for orbit corrections and attitude control to be almost completely expended. In addition, the power level from Galileo's nuclear generators will start to run too low to keep all of the science instruments powered at once. Finally, radiation exposure from Jupiter's intense belts of energetic particles will start causing electronic parts to fail. If sufficient fuel and power remain, however, the JPL flight team hopes to fly a few more orbits, extending the science mission of the spacecraft as long as possible.



Lionel Brett/SIS

PROBE WITH PARACHUTE descends through Jupiter's clouds on December 7, 1995. Instruments onboard the probe will measure atmospheric temperature, pressure, density, and composition.

The Best Is Yet to Come

Despite the loss of the high-gain antenna and the problematic tape recorder, Galileo is expected to accomplish roughly 70 percent of its original science goals. The probe's measurements in Jupiter's atmosphere, the most important scientific goal, will be fully accomplished. High-resolution imaging and compositional mapping of three Galilean satellites will be achieved. The orbiter will continuously monitor the Jupiter magnetosphere for more than two years.

The major scientific losses will be the close-up view of Io and the inability to monitor the long-term dynamics of cloud motions in Jupiter's atmosphere, a goal that requires far too many images to be accommodated with the lower data rates. Also, Galileo will be far less capable at following up on its own discoveries, because the observations have to be carefully preplanned for the limited available data rates. Nevertheless, some time has been set aside in the later orbits for sequence updates to follow up on new discoveries.

Galileo's camera team is expected to take between 900 and 1,400 pictures at Jupiter, a sharp reduction from the 50,000 pictures originally planned. "Everyone knows they are in the same boat, and that makes for a lot of cooperation," says Catherine Hefferman, a science coordinator for the camera team. "We're concentrating on what we're getting rather than what we're giving up."

By 1997, Galileo's scientists and engineers will have devoted 20 years of their professional careers to the mission. In the end, will all this effort have been worth it? The answer will have to come from them, after they see and analyze their data. "I can't imagine that there won't be startling discoveries that rival anything we have seen before," says Neil Ausman. It is a feeling echoed by all of Galileo's dedicated staff. □

You can access the latest information and images from Galileo on the Internet at:

http://www.jpl.nasa.gov/galileo

For students kindergarten through high school:

http://quest.arc.nasa.gov/jupiter.html

Paul Weissman is a coinvestigator on Galileo's Near Infrared Mapping Spectrometer team. He has been with the project since 1977. His previous ASTRONOMY *article was "Making Sense of Shoemaker-Levy 9" in the May 1995 issue. Marcia Segura is a science coordinator on the NIMS team and has worked on Galileo since 1988.*

The Star

Jeff Hester and Paul Scowen, Arizona State University, and NASA.

Giant Pillars of M16

A dramatic new HST image reveals young stars emerging from towers of interstellar gas and dust

by Jeff Kanipe

Startling new photographs taken by the Hubble Space Telescope's Wide Field and Planetary Camera 2 reveal newborn stars emerging from giant pillar-like structures in the Eagle Nebula, M16, a star-forming region 8,000 light-years from Earth. HST's high-resolution view shows never-before-seen details of stars still in the process of forming as well as those that may never be born.

The eerie images call forth columns of "smoke" billowing from sea floor volcanic vents or the gangly pillars of rock found in the desert. These structures, the tallest of which extends about two light-years, contain globules of dense gas, many of which may eventually collapse into stars.

The pictures were taken last April by Jeff Hester and coinvestigator Paul Scowen, both of Arizona State University, as part of a study of the effects of newborn and embryonic stars on the interstellar environment. Hester and Scowen were especially delighted to observe a process called photoevaporation, in which an unceasing blast of ultraviolet radiation from hot, young stars wears away the outer layers of the cold nebula, exposing denser, dusty globules of inchoate stars beneath.

Many of these evaporating gas globules (dubbed EGGs) may never develop into full-fledged stars because photoevaporation robs them of the reservoir of dusty gas from which they need to draw mass. Those globules that already contain newly formed stars eventually will emerge from their gaseous umbilical cords projecting from the main pillar.

"This is the first time we have actually seen forming stars being uncovered by photoevaporation," says Hester.

The photoevaporation evident in star-forming regions like M16 stands in marked contrast to how a star forms in isolation. Astronomers believe that a lone star will continue condensing within its gas/dust chrysalis until internal pressures ignite nuclear fusion in its core. When this happens, the radiant energy from the young, hot star creates a strong "wind" that whisks away the residual material.

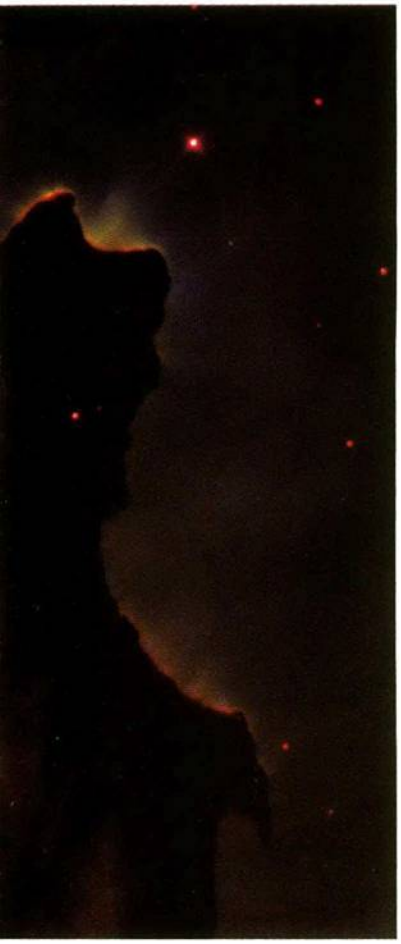
In the case of M16, however, intense ultraviolet energy from numerous existing stars is flooding the whole stellar incubator, resulting in fully formed and stillborn stars.

Careful scrutiny of the HST images reveals many fascinating details. In places, stars just emerging from their EGGs appear like flames atop a narrow candle. Finger-like protrusions along the tops and sides of the nebula are the EGGs themselves. Each fingertip is somewhat larger in diameter than our solar system. Some of the EGGs have been pinched off from the nebula and look like gray droplets in space.

The photoevaporation process is most apparent in the wispy streamers seen along the tops of the cloud pillars. The EGGs, which are denser than their surroundings, remain after the gas around them is gone.

The otherworldly quality of the three pillars is enhanced by a drapery of semi-transparent dust hanging like a grimy window from the smaller of the three towers. A scattering of dull red stars shining like feeble Christmas lights in the shadows of the towers conveys a sense of the vast dimensions of the structures.

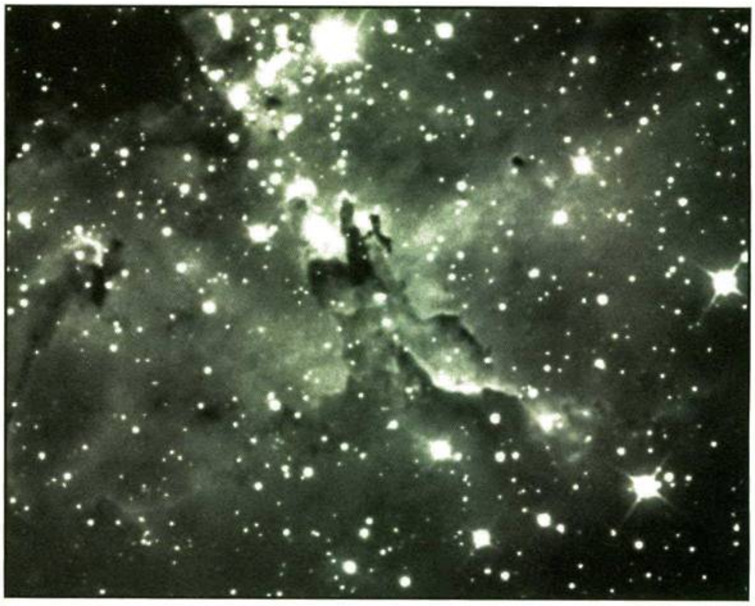
Hester plans to use Hubble to probe other nearby star-forming regions for similar structures. Discoveries about the nature of the M16 EGGs, he says, might lead astronomers to rethink some of their ideas about the environments of stars forming in other regions, such as the Orion Nebula. ☐



WEATHERING HEIGHTS. Giant gaseous pillars in the star-forming nebula M16 are being eroded by hot young stars, exposing newborn stars as well as preventing the births of undeveloped stellar embryos.

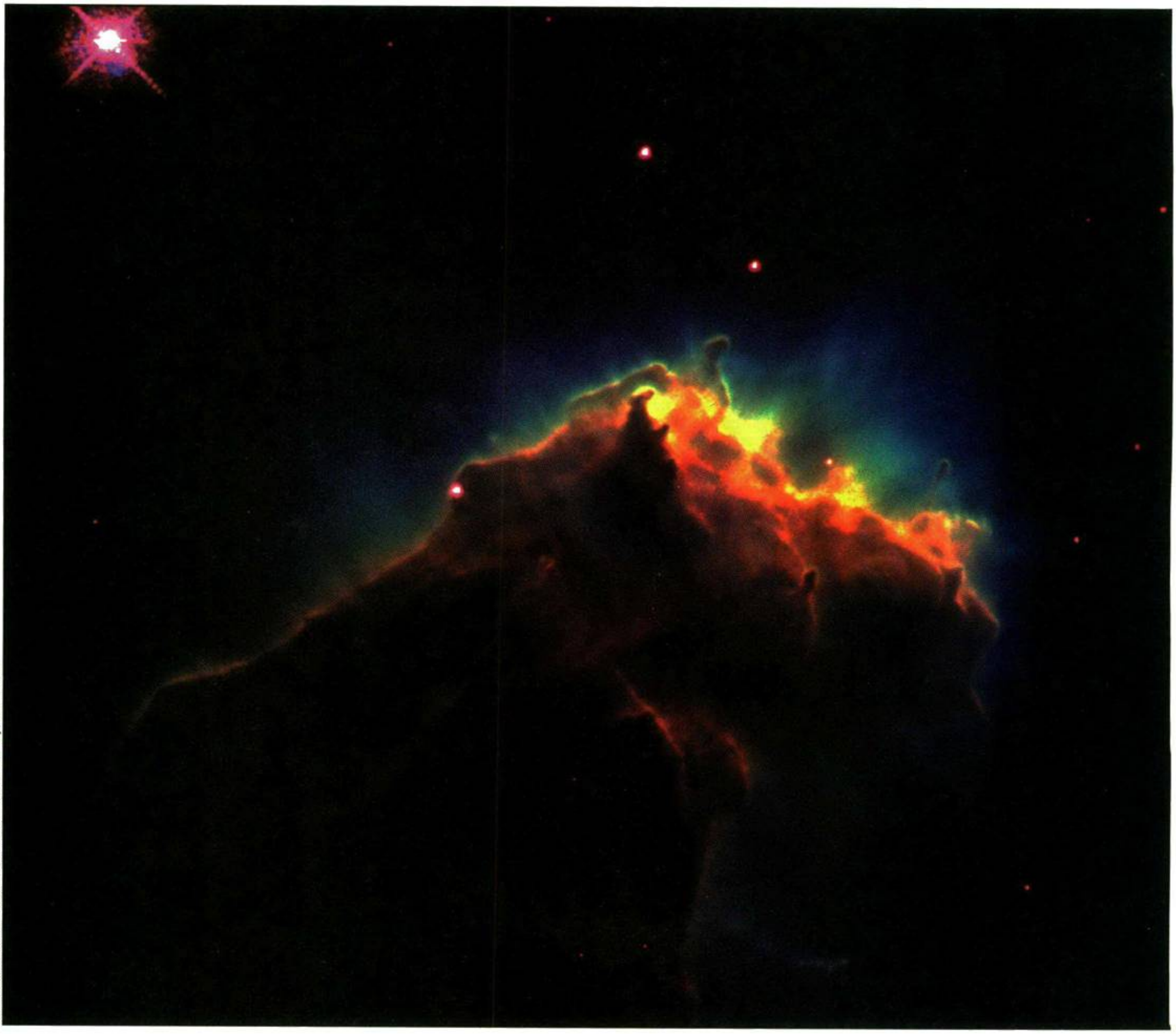
Jeff Kanipe is the managing editor of this magazine.

A CONVENTIONAL VIEW OF M16 centered on the same region imaged by HST taken with a 12-inch telescope. The tallest pillar is slightly overexposed .

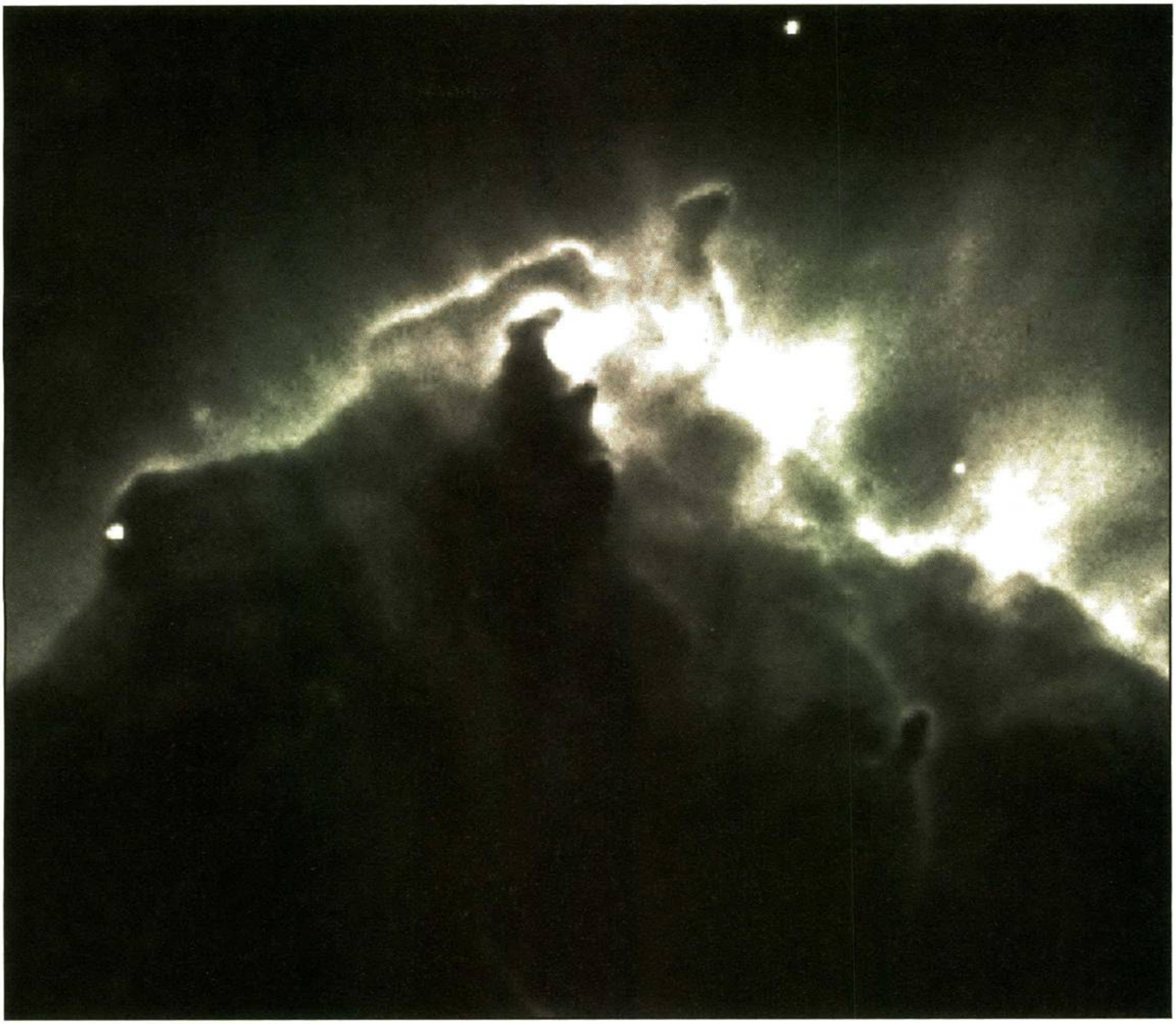


Preston Scott Justis

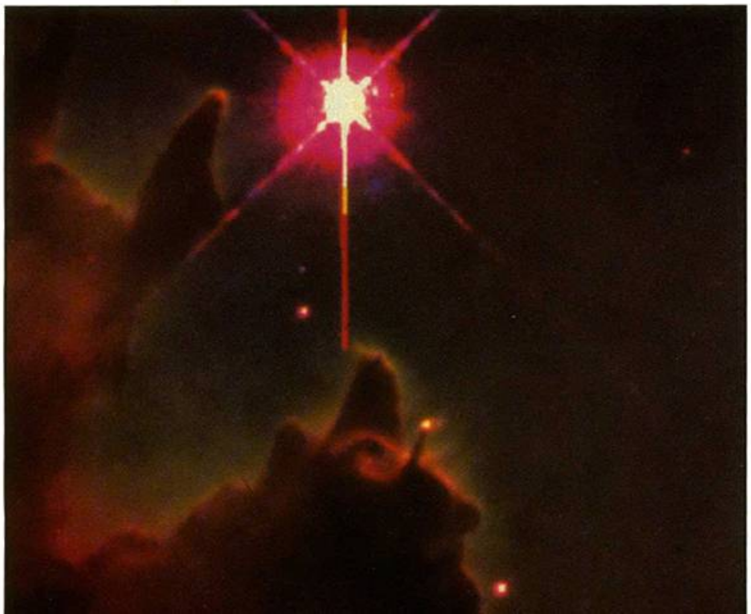
STELLAR EMBRYOS IN M16 appear as finger-like projections in this close-up view of the top of the tallest star tower. Each dense globule acts as shield protecting an umbilical of gas from the onslaught of ultraviolet radiation from nearby hot young stars. These embroys, which astronomers have dubbed EGGs, are seen in more detail in the close-up view, opposite page.



Jeff Hester and Paul Scowen, Arizona State University, and NASA.



Jeff Hester and Paul Scowen, Arizona State University, and NASA.



Jeff Hester and Paul Scowen, Arizona State University, and NASA.

A NEWLY BORN STAR peeps out at the universe from the tip of its EGG cocoon.

SECOND CHANCE Planets

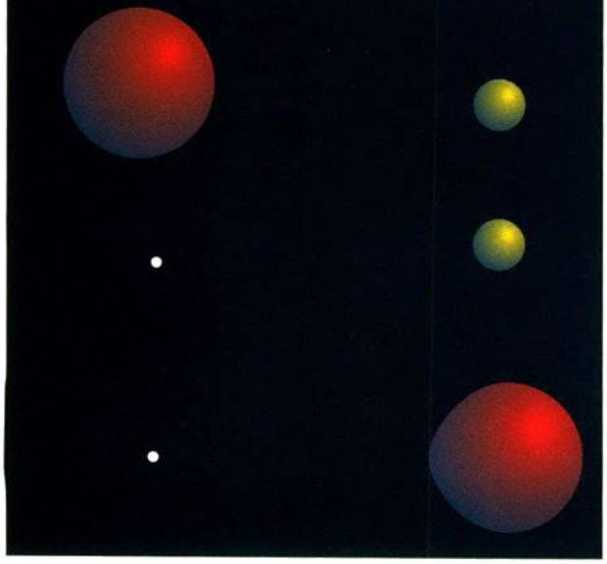
A pulsar is a tough environment to grow a planet in. So how did one pulsar make a small solar system?

by Sally Stephens

The last place astronomers ever thought to look for planets was around a pulsar. Born in the explosive self-destruction of massive stars, pulsars emit tremendous amounts of energy, much of it in a beam that sweeps through space like a lighthouse beacon. This environment is not at all like the nurturing one in which our solar system formed, where small dust grains grew slowly into planets near a relatively quiet Sun.

And yet, orbiting a pulsar is exactly where Penn State University radio astronomer Alex Wolszczan found the first planets confirmed to exist outside our solar system. In the four years since his announcement, astronomers have tried to understand how planets could form in an environment that at first glance seems so hostile. In the process, they hope to learn whether planets are common in the Galaxy, which may tell them something about whether or not we are alone.

FORMING A MILLISECOND PULSAR. The larger member of a binary pair explodes, forming a pulsar. When its companion becomes a red giant, material spills onto the pulsar, causing it to spin faster.



ASTRONOMY: Phil Kirchmeier

Cosmic Clocks

Astronomers had been studying pulsars for years before they realized some might have planets. These bizarre objects emit pulses of radio energy with such clocklike regularity that the astronomers who discovered the first one initially thought the pulses might be a sign of an alien civilization. But they soon realized that a rapidly spinning, compact star — not Little Green Men — was responsible.

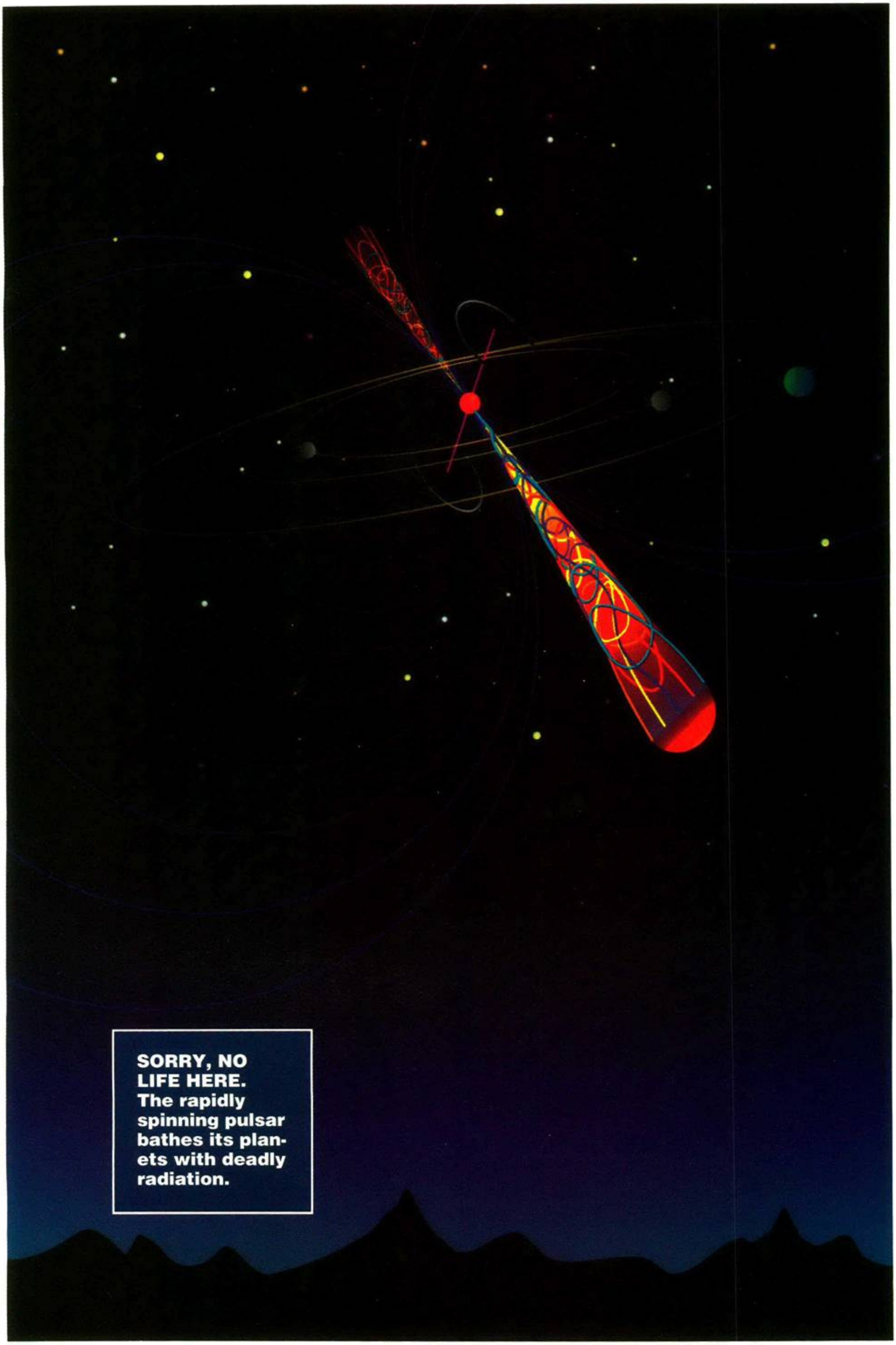
As massive stars use up the last of their nuclear fuel, their cores collapse suddenly and catastrophically, triggering a supernova explosion. The star's outer layers are violently ejected into space, sweeping the region around the star clear of debris. The core contracts until its matter is so tightly compressed that electrons and protons are squeezed together into neutrons. It becomes a neutron star, with more mass than the Sun squeezed into an object about the size of a city. A tablespoon of neutron star stuff would weigh as much as a mountain.

Because of their small size, neutron stars spin much faster than normal stars. The Sun takes about a month to turn once on its axis, most neutron stars take less than a second. The incredible spin of a neutron star generates enormous amounts of energy, which travels in beams outward from the star's magnetic poles. If one of the beams sweeps across our field of view, we see a flash of energy, just as a sailor sees a lighthouse beacon that warns of dangerous rocks. These pulses of energy give pulsars their name.

A few pulsars rotate extremely rapidly, spinning a hundred times (or more) each second. These "millisecond pulsars" emit their pulses with a regularity that rivals the most precise atomic clocks on Earth. Astronomers can measure the arrival times of the radio pulses to an accuracy of 3 microseconds (that's 0.000003 second!). They can predict with astonishing precision when the next one will arrive, and the next, and the next. . .

Three, Maybe Four Planets

Four years ago Alex Wolszczan (pronounced VOL-shtan) was observing the millisecond pulsar PSR 1257+12 (named for its coordinates on the sky), which he and Dale Frail of the National Radio Astronomy Observatory in Socorro, New Mexico, had just discovered with the 305-meter Arecibo radio telescope in Puerto Rico. A relatively old pulsar (close to a billion

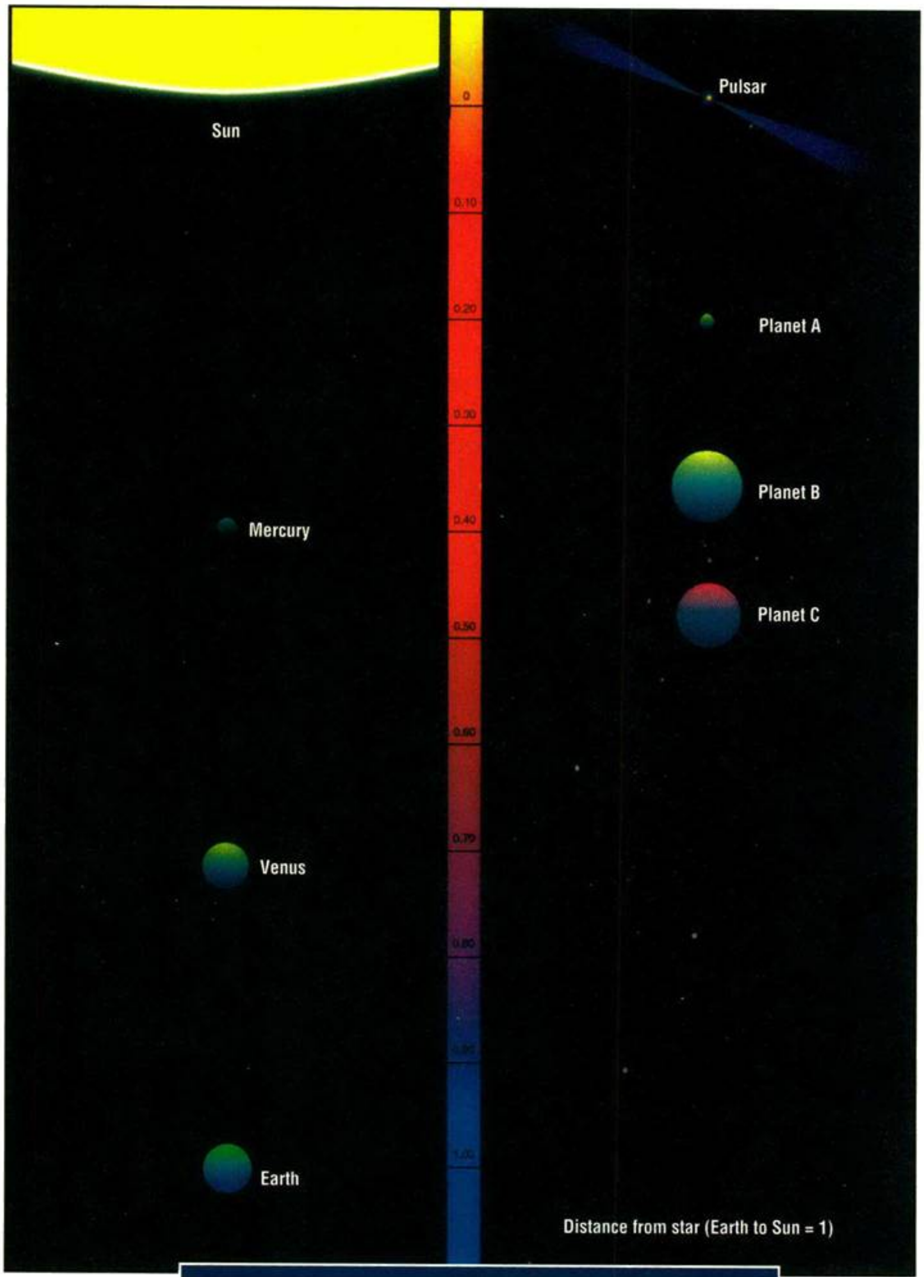


SORRY, NO LIFE HERE. The rapidly spinning pulsar bathes its planets with deadly radiation.

James Collins/Penn State Univ.

years old) located about 1,600 light-years away in the constellation Virgo, it spins 161 times each second. Wolszczan noticed that sometimes the pulses came a few milliseconds earlier than predicted, and sometimes a few milliseconds later. Then he realized that the arrival-time variations weren't completely random, but seemed somewhat periodic. "This was very untypical of an old millisecond pulsar," he recalls. As he further analyzed the patterns, Wolszczan discovered two periods: one lasting 66.6 days, the other 98.2 days. "At that point, I knew postulating planets around 1257+12 was the best way to go."

Several months earlier, another astronomer had proposed that variations in the arrival times from a different pulsar might be due to the presence of an orbiting planet. As the pulsar nodded ever-so-slightly in response to the planet's gravitational tug, it moved, alternately, a little bit closer to and then slightly farther away from us. Consequently, its radio pulses arrived, respectively, slightly earlier than expected and slightly later. This planet discovery was later found to be in error, but the seeds of pulsar planets had been planted.



James Collins/Penn State Univ.

A WEIRD SOLAR SYSTEM. The diminutive pulsar's planets orbit close in. Two of the three planets are more massive than Earth, the third has the mass of the Moon.

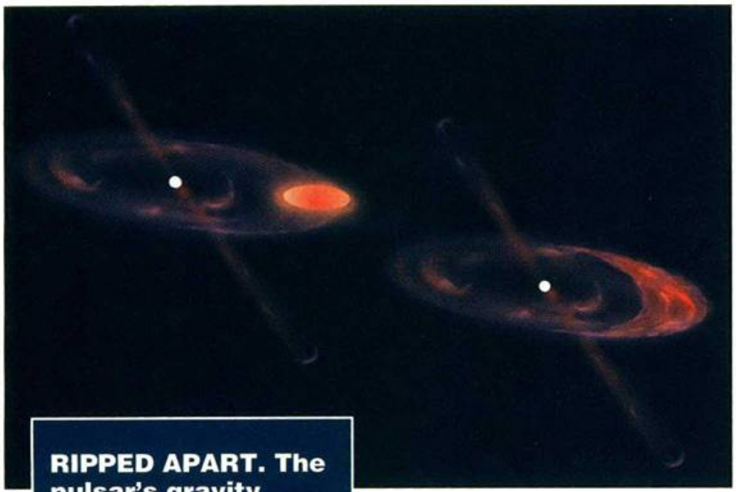
Wolszczan and Frail initially proposed that two Earth-sized planets orbited the pulsar. One, with a mass at least 3.4 times that of Earth, orbits 54 million kilometers from the pulsar (.36 AU); the other, at least 2.8 times more massive than Earth, orbits about 70 million kilometers (.47 AU) away. Both orbits are very nearly circular and are at about the same distance Mercury orbits the Sun.

At the time of Wolszczan and Frail's announcement, some astronomers remained skeptical of their claim. Perhaps something strange was happening inside the neutron star, causing the periodic motion. Or maybe the star's rotation axis was wobbling like a spinning top. All doubts vanished in 1994, however, when Wolszczan reported that continued monitoring of the radio pulses showed very slight, additional changes in the arrival times caused by the effects on their orbits of gravitational interactions between the two planets. No other explanation could account for the new perturbations.

The additional observations also revealed a third planet, about the mass of the Moon (0.015 times that of Earth), orbiting a mere 28 million kilometers (.19 AU) from the pulsar. And there are tantalizing hints that a fourth planet may orbit much farther away than the other three. It's orbital period is longer than the five years of data that have been gathered on the system so far. Until Wolszczan has observed it over at least one complete period, he can't say much about its properties. "It might be a low-mass object in, say, a five-year orbit, or something much more massive in a 25-year orbit," he says. "As always, we need more time, more observations."

Where Did They Come From?

Discovering that planets orbit a millisecond pulsar is only half of the story. Astronomers want to understand how they got there. Our solar system formed out of a thin disk of gas and dust that surrounded the young Sun. Presumably pulsar planets also formed out of some kind of disk. But where did the disk come from? "I would say that there are at least a dozen different scenarios that have been proposed," says Fred Rasio of



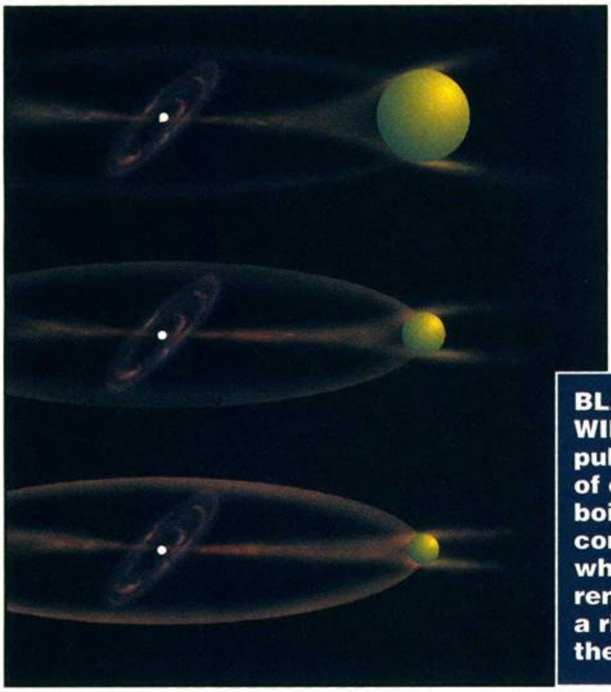
Astronomy: Phil Kirchmeier

RIPPED APART. The pulsar's gravity destroys its companion, whose material forms a protoplanetary ring around the pulsar.

MIT. Most of these scenarios take note of the fact that a majority of millisecond pulsars have a stellar companion.

The idea follows naturally from current models of how millisecond pulsars form. Astronomers think they start out as "normal" pulsars, born when one star in a binary system reaches the end of its life and blows apart, leaving behind a neutron star that spins a few times every second. Somehow, the companion survives the explosion. As it ages, its outer envelope expands until finally gas from its outer layers spills over onto the neutron star, forming a disk. The flow of gas causes the pulsar to spin faster and faster, much like wind blowing harder and harder on a windmill makes its blades spin more rapidly. In time, the neutron star's spin rate accelerates to a hundred times a second; it's become a millisecond pulsar.

This process usually doesn't destroy the companion, however. PSR 1257+12 is one of the few millisecond pulsars known that is not in a binary system; it travels alone through space. So to explain it, you have to somehow get rid of the companion and still form a disk. A number of ideas have been proposed. In one scenario, the companion, unable to shed material onto the pulsar quickly enough, is torn apart as it expands. Or, perhaps intense radiation from the pulsar boils material off the companion until finally there is nothing left of the star. Astronomers have found several pulsars where this appears to be happening. "They're called black widow binaries," says Rasio. "The pulsar is destroying its mate." The evaporated material forms a disk around the widowed pulsar.

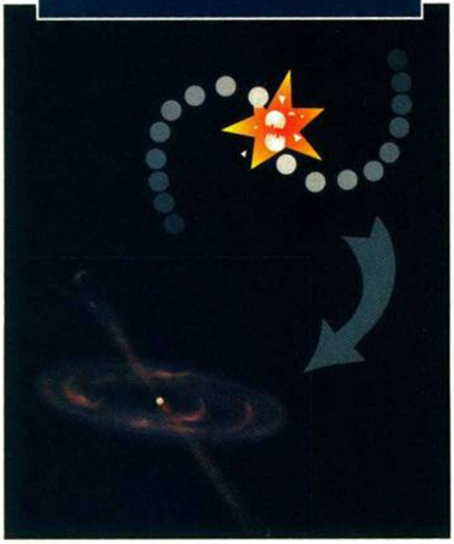


Astronomy: Phil Kirchmeier

BLACK WIDOW. The pulsar's beam of energy boils away its companion, whose remains form a ring around the pulsar.

In another scenario, the initial binary system consists of two white dwarf stars that orbit close together. They slowly spiral in toward each other, eventually getting so close that they literally merge into a single object. During the merger process the stars eject some material, which winds up in a surrounding disk. If conditions are right, the merged object, now too massive to remain a white dwarf, collapses into a rapidly spinning neutron star. "I like the idea of white dwarf collisions," Wolszczan says. One problem with this idea is preventing a runaway thermonuclear explosion as the two stars merge. Such an explosion would destroy both white dwarfs, leaving nothing behind.

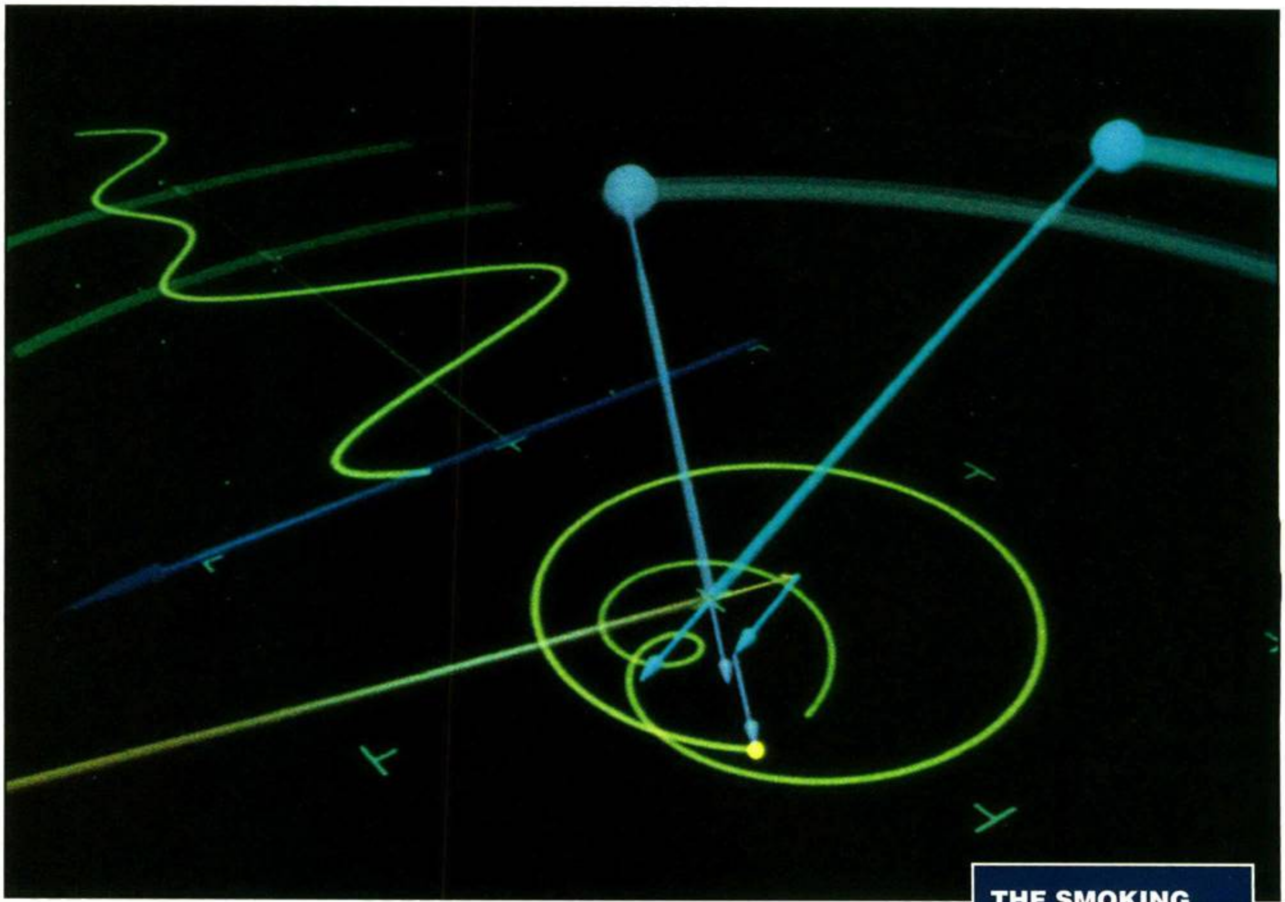
FATAL ATTRACTION. Two white dwarfs spiral inward. They merge, forming a pulsar. Ejected material forms a ring.



Astronomy: Phil Kirchmeier

Still another scenario suggests that a small amount of gas violently ejected during the supernova could fall back toward the neutron star, settling into a disk around it. But computer models of this process suggest the material would settle much closer to the pulsar than the distances of the observed planets. And there may not be enough material to form more than one planet. Other astronomers have suggested that asymmetric supernova explosions might not blow away some pre-existing planets. However, this requires so many things to happen in just the right way that it seems highly unlikely. And the most massive stars might not live long enough to form planets in the first place.

Perhaps the neutron star is able to quickly acquire a massive envelope of


JAMES COLLINS/PENN STATE UNIV.

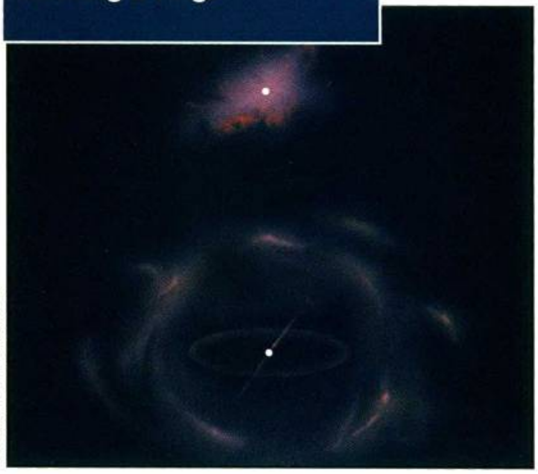
THE SMOKING GUN. The pulsar planets interact with one another, causing subtle changes in the arrival times of the pulsar's radio signal. Alex Wolszczan observed this effect, proving the planets were for real.

stellar material, either through a collision or merger with a normal star. Such an envelope would not last long, given the enormous energy outflow from the pulsar. But, if the envelope deflated suddenly, its material might settle into a disk around the neutron star.

An earlier idea that a pulsar could "steal" planets from a Sun-like star during a close encounter has fallen out of favor. The model was developed to explain an apparent planet orbiting a pulsar in the globular star cluster M4. Stars are packed so tightly together in globular clusters that such encounters could be fairly common. However, more accurate measurements of the M4 pulsar system revealed that what was thought to be a planet is probably a low-mass star.

Fallback, preexisting planets, and mergers cannot account for the extremely rapid rotation of millisecond pulsars, so they can't explain the mystery of PSR 1257+12. But they might prove useful should planets ever be found orbiting a young, slowly rotating pulsar. "There are lots of ways of ending up with a system in which you have a pulsar in the center, and some material in an outer disk," Rasio says. "And then, presumably, out of that disk you form planets."

INFALL. A star goes supernova, forming a pulsar. Some of the gas thrown into space by the explosion falls back, forming a ring.


ASTRONOMY: Phil Kirchmeier

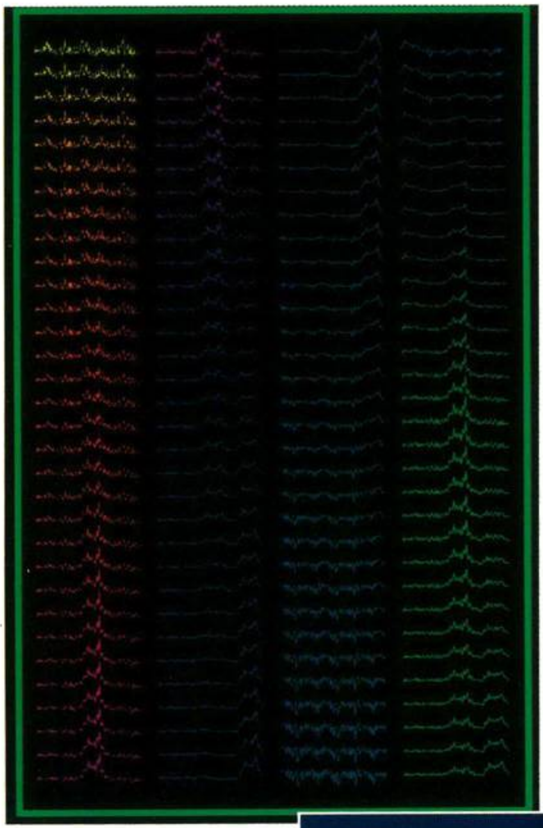
The problem is that so little is known about pulsar planets that it's nearly impossible to rule out any theory. With only one system to study, scientists can't assess competing theories.

Other Pulsars, Other Planets

Still, astronomers can learn a lot from only one pulsar planetary system. "You've found a planet that could be just like Earth around an object that's as completely different from the Sun as you can possibly imagine," notes Rasio. Clearly the process of planetary formation is less sensitive to the central object than astronomers had previously thought. "Nature doesn't really care how a star or a pulsar ends up having a protoplanetary disk around it," adds Wolszczan. "It takes it from there and makes planets using essentially the same physics, no matter if you have a Sun-like star or a pulsar."

Some astronomers had argued that there might be something special about the conditions that existed

To obtain images and information about pulsar planets, access the following site on the Internet:
http//www.astro.psu.edu/users/pspm/planets.html



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CLOCKLIKE PRECISION. Or actually, better than a clock. Subtle changes in a pulsar's radio signal arrival times betrayed the presence of three planets.

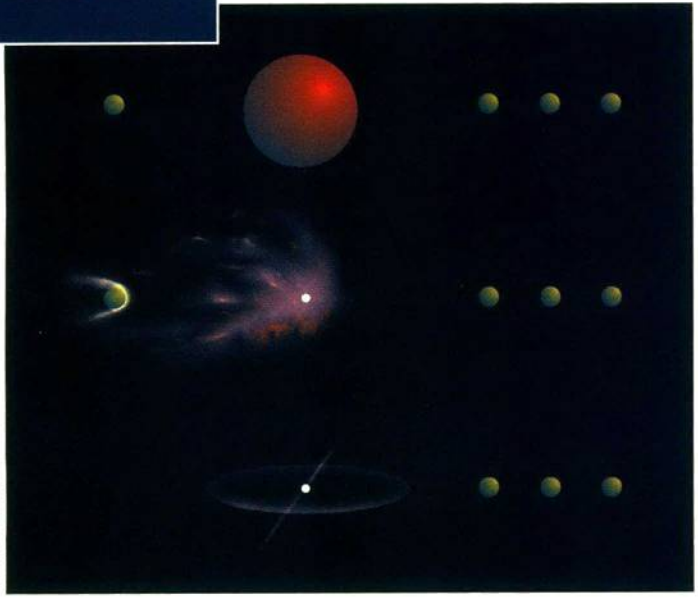
around the young Sun that allowed our solar system to form. If that was true, you might expect to find other planets only around stars like the Sun, if they exist at all. The discovery of pulsar planets changed all that. "This tells you that planets form in a variety of environments," says Rasio.

The existence of pulsar planets implies planets may be fairly common in the Galaxy. And that's encouraging to anyone searching for signs of extraterrestrial intelligence. "If you're going to ask whether there's any kind of life as we know it elsewhere in the universe," Rasio explains, "the first thing you have to consider is whether there are planets around other stars."

But there is almost certainly no life on the pulsar planets, even though they are about the same size as Earth. "I think it's pretty clear," Rasio says, "that if you took any form of life as we know it here and you put it there, it would die in an instant." The environment around the pulsar is just too inhospitable. "The pulsar's energy may heat the planets up to some 600 to 700 kelvins," Wolszczan speculates, "and it may bathe them in high-energy radiation and streams of relativistic particles."

Although the planets themselves are probably devoid of life, their mere existence has caused quite a stir. Radio astronomers are now reexamining old pulsar timing data for previously unnoticed periodic variations in pulse arrival times. It's not an easy job. All pulsars show small, nonperiodic fluctuations in their pulse arrival times, an effect known as "timing noise." It's not clear what causes timing noise, but it's stronger in young pulsars while only a tiny effect in millisecond ones. Still, it can be mistaken for the signature of planets if the analysis is not done carefully. However, if you calculate an orbit based on the timing noise rather than a real planet, it will rather quickly fail to accurately predict future pulse arrival times. Within a year or so it will become obvious that the fluctuations were not truly periodic, and were not caused by planets.

TOUGH GUYS. Perhaps a few planets survived the supernova, a possibility if the explosion was more intense in one direction.



ASTRONOMY: Phil Kirchmeier

So far, astronomers have not uncovered any other planets in their old data. "We know now that not all millisecond pulsars have planets," Rasio explains. "It was not just a question of going back and looking for them. People have done that, and they have not found them." There are persistent reports that a three-planet system may have been found around a young pulsar. But until those reports can be confirmed, the millisecond pulsar PSR 1257+12 remains the only one known to have a retinue of planets. Although there are indications that they should be common, discovering more planetary systems may prove difficult. "It could still be a very rare occurrence," Rasio notes. "It's just that Alex Wolszczan was incredibly lucky." ☐

Sally Stephens is a science writer living in San Francisco. Her previous ASTRONOMY *article, "Needles in the Cosmic Haystack," appeared in the September 1995 issue.*

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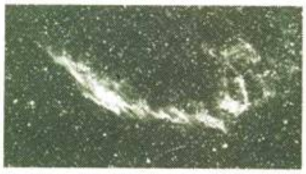

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6'' f/8 Equat. Starfinder 6(add $79 P&S)	**$599**
8'' f/6 Dobsonian Starfinder (add $59 P&S)	**$425**
8'' f/6 Equat. Starfinder 8 (add $89 P&S)	**$699**
10'' f/4.5 Dobsonian Starfinder ($85 P&S)	**$595**
10'' f/4.5 Equat. Starfinder 10 (add $99 P&S)	**$799**
12.5'' f/4.8 Dobsonian Starfinder ($95 P&S)	**$795**
16'' f/4.5 Starfinder 16 (ship. freight COD)	**$2495**

*All Starfinder telescopes shipped directly from Meade to the purchaser. Please add the indicated packing & shipping charge to the price. Slightly lower P&S for payment by check. LUMICON showroom prices are $99 higher.

ACCESSORIES

LUMICON carries all Meade accessories.

LUMICON Single axis drive corrector	**$99**
LUMICON DX200 Dual-axis drive cor.	**$249**
Meade 47M Dual-axis drive corrector with tangent arm & electric declination	**$475**
LUMICON DX2BP Dual-axis drive corrector with built-in battery pack	**$299**

SKY VECTOR™ $249!!

New Lower Prices — Higher Performance

LOW PRICE—from $249

LUMICON SKY VECTOR FEATURES:

- "GUIDE" mode leads you to object
- Digital right ascension readout to 1 min.
- Digital decl. readout to 10 arc-min.
- 4000 pulse (0.09° accuracy) encoders
- Polar alignment ***not required!***
- Motor drive ***not required!***
- Just sight two stars to align!
- Works **equally well** for alt-azimuth telescopes like Coulter Odyssey and equatorial mounts like C-8, Meade 2080.
- **No need** to enter latitude, longitude, etc.

SKY VECTOR I™ $249

NEW! With over 220 object memory including the 110 Messier and 58 best NGC objects.

SKY VECTOR II™ $289

IMPROVED — Planets, Over 3,700 Objects! With size, magnitude and full visual description.

NGC SKY VECTOR™ $389

IMPROVED!—5500 Additions / Corrections

NGC-Sky Vector™
OFF ON
DIM
MODE
ENTER
UP
DOWN
LUMICON®

Improved NGC SKY VECTOR with over 12,000 object memory including the planets, complete, corrected RNGC catalogue, IC catalogue, P&K planetary catalogue, & much more!

Specify Telescope Type: Meade 2045, 2080, 2120, C-8, C-11, Odyssey 8, 10, 13, 17½, Alt-Azimuth.

Ultima 8, 11 .. **add $25**, C-14 .. **add $75**

COMA CORRECTOR

Coma 1 inch off-axis 17½'' f/4.5

Same field with LUMICON coma corrector; smaller, more numerous stars.

This computer-designed LUMICON 2'' lens reduces coma and flattens the field for both viewing and photography. **It threads into LUMICON 2'' EASY-GUIDERS for effortless installation.** This zero power lens does not change image scale nor shift focus, and all lens surfaces are multi-coated for highest efficiency. Clear aperture = 1.8''.

LUMICON 48mm Coma Corrector/Field Flattener Lens	**$285.00**
LUMICON 2'' EASY-GUIDER	**$189.50**
2'' EASY-GUIDER (Mamiya 645)	**$239.50**
2'' Adapter for Pentax 6X7	**$129.00**
2'' Adapter for Hasselblad	**$229.00**
2'' Adapter for Bronica SQ-A	**$175.00**
2'' Extension for viewing	**$26.00**

2'' DELUXE BARLOW

1.8x Multiplier Lens (2'' Barlow)

LUMICON 1.8x Multiplier Lens (2'' Barlow)	**$259.00**

LUMICON ACCESSORIES

LUMICON, Livermore, CA 94550 (510) 447-9570 FAX (510) 447-9589

LARGE UV/DUST SEAL

Protect the optics of your 8-14'' Schmidt-Cassegrain with a UV/Dust Seal. Simply thread it onto the rear cell, then attach all normal accessories. The large size fits Meade 2120, Celestron-11 and -14 & has a high quality multi coated (removable) 72mm UV filter.

Deep-Sky Filter/Dust Seal for C-8, 2080	**$119.50**
UV/Dust Deal for Celestron C-8	**$39.00**
UV/Dust Seal for Meade 2080, 2045	**$39.00**
UV/Dust Seal (large) for Meade 2120	**$89.50**
UV/Dust Seal for Celestron-11, -14	**$89.50**

LOW PROFILE FOCUSERS
New! Thread-on for Odyssey

FROM $69.50

LUMICON® LOW PROFILE FOCUSERS

LUMICON now offers 3 different low-profile helical focusers. They stand only 1¼-1½'' above the telescope tube. Use the 1¼'' or 2'' versions for viewing. Use the 2'' non-rotating focuser for convenient photography with the LUMICON 2'' EASY-GUIDER™.

Select your desired base-plate shape! Coulter Odyssey (thread-on installation), Flat, 7'' OD, 9½'' OD, 12½'' OD, 16'' OD, 21'' OD.

LUMICON 1¼'' Helical Focuser	**$69.50**
LUMICON 2'' Helical Focuser 1½'' high	**$75.00**
LUMICON Non-rotating Helical Focuser	**$129.00**
2'' Astro Systems focuser, only 2'' high	**$139.00**
3 handles for non-rotating focuser	**$12.95**
2''/1¼'' adapter w/48mm filter threads	**$20.00**
2'' LUMICON EASY-GUIDER	**$169.50**

LUMICON 50mm, 80mm SUPER-FINDER™

Visual Astronomers prefer the LUMICON 80mm SUPER-FINDER™, since hundreds of deep-sky objects, including most Messier objects, are visible directly. SUPER-FINDERS also make nice small portable telescopes. 80mm aperture, F=300mm coated achromat or 50mm, F=200mm coated achromat. Eyepieces and/or star diagonal are extra.

1¼'' 50mm Finderscope **$69.50**, right-angle	**$69.50**
1¼'' straight-thru 80mm SUPER-FINDER	**$189.50**
1¼'' right-angle 80mm SUPER-FINDER	**$199.50**
1¼'' right-angle version, w/star diagonal	**$239.50**
25mm Cross-hair 1¼'' eyepiece (12X)	**$49.00**
Large mounting rings for 80mm Finder	**$55.00**
1¼'' Star Diagonal **$49**, Mounting Brackets,	**$39.50**
1¼'' 45° diagonal for correct left-right views	**$59.50**

LOTS OF ADAPTERS

2'' adapter for C-8, Meade 2080, etc.	**$29.50**
2'' adapter for C-80, C-100 refractor	**$39.50**
2'' adapter for C-70, C-80F, C-100F fluorite	**$39.50**
2'' adapter for C-6, Comet Catcher, Meade 312	**$30.00**

EXTENSION TUBES

1'' long 1¼'' OD thread-in extension	**12.00**
2½'' long extension (holds 1¼'' filters)	**19.50**
4½'' long extension for 1¼'' eyepieces	**$25.00**
3'' long extension for 2'' eyepieces*	**$29.00**
2'' long extension for 2'' eyepieces*	**$29.00**

VIEWING ADAPTERS

2''/1¼'' reducing bushing,threaded 48mm*	**$25.00**
2''/T-thread adapter, threaded 48mm*	**$25.00**
T-thread/1¼'' adapter	**$25.00**
F/10 2'' or 1¼'' eyepiece viewing adapter for Giant Easy-Guider	**$39.50**
Low profile star diagonal eyepiece holder	**$16.00**
Meade 2'' Diagonal/Giant Easy-Guider	**$39.50**

**Threaded to hold 48mm filters.*

CIRCLE NO. 16 ON THE READER SERVICE CARD

SKY ALMANAC

Highlights
by Alister Ling

Date	Event
18	Jupiter and the Moon Greet Dawn . . . . (p. 66)
22	The Moon Brushes Venus & Saturn . (p.63)
29	Moon in the Heart of the Hyades. . . (p. 58)
All month:	
	First Views:
	Summer Triangle's Winter Finale . .(p. 63)
	Follow Asteroid Irene through Cancer (p. 65)
	Find Comet Honda-Mrkos-Pajdusóková . .(p. 65)
	Betelgeuse the Variable . . . . . .(p. 67)
	Observer's Challenge:
	Supernova Remnant IC443 . . . .(p. 67)
	The Starry Sky:
	Gemini . . . .(p. 64)

Mercury and Jupiter are challenging targets during evening and morning twilight, respectively, while Saturn's narrow rings and a waning Venus beckon in the west shortly after sunset.

by Deborah Byrd

Welcome to the dead of winter. January's planets seemingly huddle around the Sun for warmth like moths around a backyard light, as winter's icy-bright stars look down upon this, the coldest time of year.

The first thing any Northern Hemisphere skywatcher notices during winter (other than the cold) are the many bright stars. Because the winter stars look so bright, many get the erroneous impression there are more naked-eye stars to see in winter than in summer. In truth, fewer stars occupy the winter sky, for we are looking in a direction opposite the star-rich center of the Milky Way Galaxy.

For the most part, winter's luminaries are intrinsically bright, blue-giant stars that reside in the same spiral arm of the Galaxy. Then again, some winter stars are simply brighter because they are nearby. Such is the case for the sky's brightest star, a star that almost everyone can identify, Sirius, in the constellation Canis Major the Greater Dog. This star shines at magnitude –1.5, making it about 10 times brighter than its closest rival. Sirius is brilliant because it is close to our Sun and Earth, shining across a distance of only 8.6 light-years.

Sirius lies rather far to the south in the sky and as a result attracts another, more notorious, kind of attention. Unless you see it at its highest in the sky — when it shines like an icy diamond above the southern horizon — you will likely be looking at Sirius through a great thickness of Earth's atmosphere. This abundance of air causes the bright star to twinkle profoundly. Indeed, the name Sirius comes from a Greek word meaning "the trembling one."

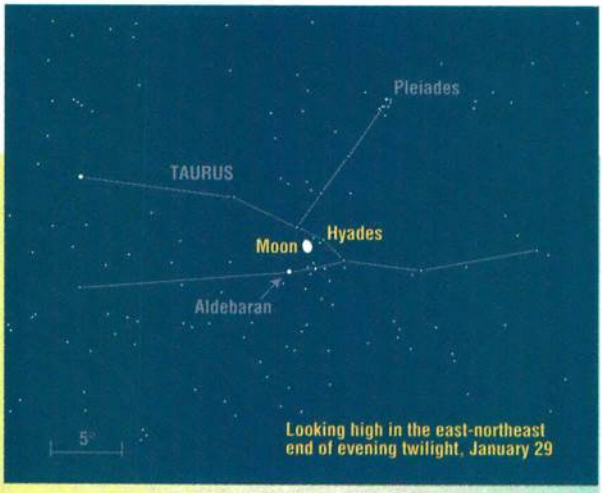
As it shimmers and dances above the southern horizon, Sirius flashes different colors. People who assume that all stars are white often first notice Sirius for its myriad of flashing colors. Some jump to the conclusion that they're seeing a marauding UFO. Indeed only far brighter Venus garners more UFO reports from concerned citizens.

This confusion fails to detract from a lovely coincidence that the sky's second brightest star lies near Sirius. If you live at a northerly latitude, you may never see this star, which lies even farther south than Sirius: Canopus in the constellation Carina the Keel.

Canopus shines at

[continued on page 59]

Moon in the Heart of the Hyades



Looking high in the east-northeast end of evening twilight, January 29

Send the Moon across a field chock full of bright stars and it's bound to cover a star or two. As the gibbous Moon cruises just north of Taurus the Bull's bright reddish star Aldebaran on the evening of January 29, it passes in front of, or occults, several bright stars in the Hyades. Check out the scene just before 7:30 p.m. EST, when stars start vanishing behind the Moon's dark limb.

The best way to catch an occultation is to observe at medium to high power through a telescope using a clock drive. Keep as much of the Moon's lit portion outside the field of view in order to reduce glare. This lets you watch faint stars wink out as they pass behind the darkened limb. Because the Moon lacks a murky atmosphere, this happens in the blink of an eye.

Not only does the Hyades star cluster make for interesting occultations, it provides a crucial yardstick in modern cosmology. Astronomers use the cluster's distance to calibrate methods for estimating the much greater distances to galaxies far away. Despite appearances, Aldebaran lies in front of the Hyades and is not a member of the cluster, which astronomers have measured to be moving in a different direction. — *Alister Ling*

JANUARY

1 Mars passes 1.6° south of Neptune, 2 a.m. EST

2 Mercury is at greatest eastern elongation (19°), 11 a.m. EST

4 Earth is at perihelion (91.4 million miles from the Sun), 2 a.m. EST
Quadrantid meteor shower peaks

5 The Moon is at apogee (252,603 miles from Earth), 6:33 a.m. EST
Full Moon is at 3:51 p.m. EST

7 Mars passes 0.6° south of Uranus, 7 p.m. EST

12 Mercury passes 3° north of Mars, 7 p.m. EST

13 Last Quarter Moon is at 3:45 p.m. EST

15 Neptune is in conjunction with the Sun, 10 p.m. EST

18 The Moon passes 5° north of Jupiter, 3 p.m. EST (page 66)
Mercury is in inferior conjunction, 5 p.m. EST

19 The Moon is at perigee (221,986 miles from Earth), 6:07 p.m. EST

20 Asteroid Irene is at opposition (page 65)
New Moon is at 7:50 a.m. EST

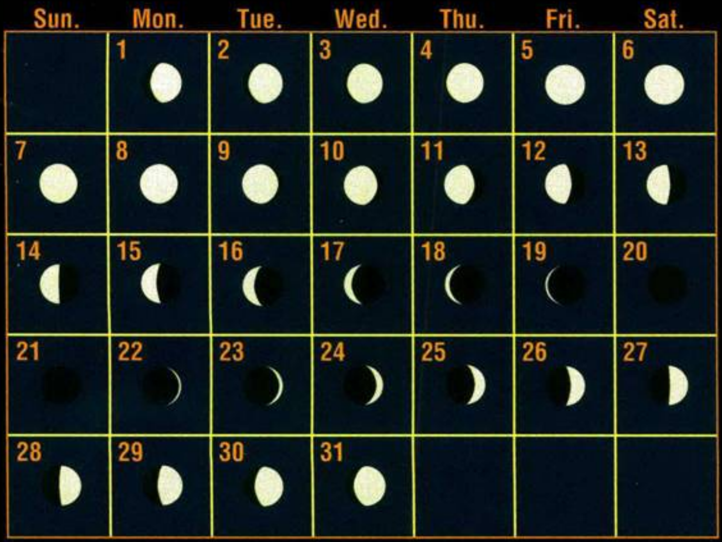
21 Uranus is in conjunction with the Sun, 2 a.m. EST

23 The Moon passes 5° north of Venus, 3 a.m. EST (page 63)
The Moon passes 5° north of Saturn, 11 p.m. EST

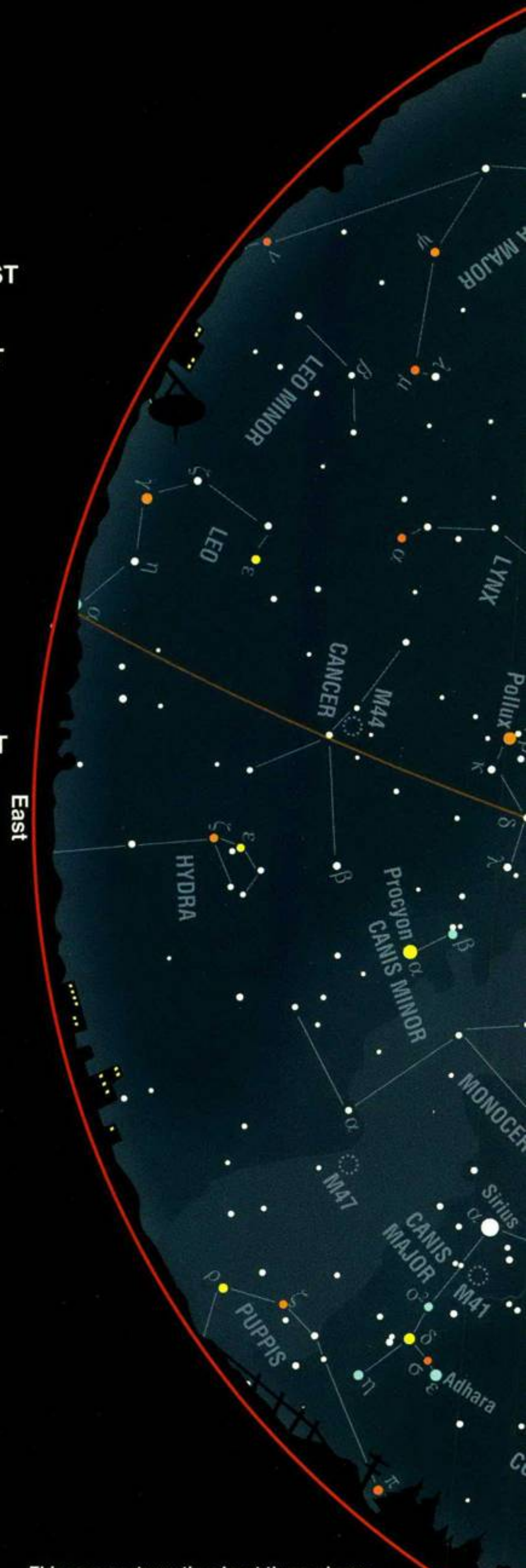
26 Asteroid Juno is in conjunction with the Sun

27 First Quarter Moon is at 6:14 a.m. EST

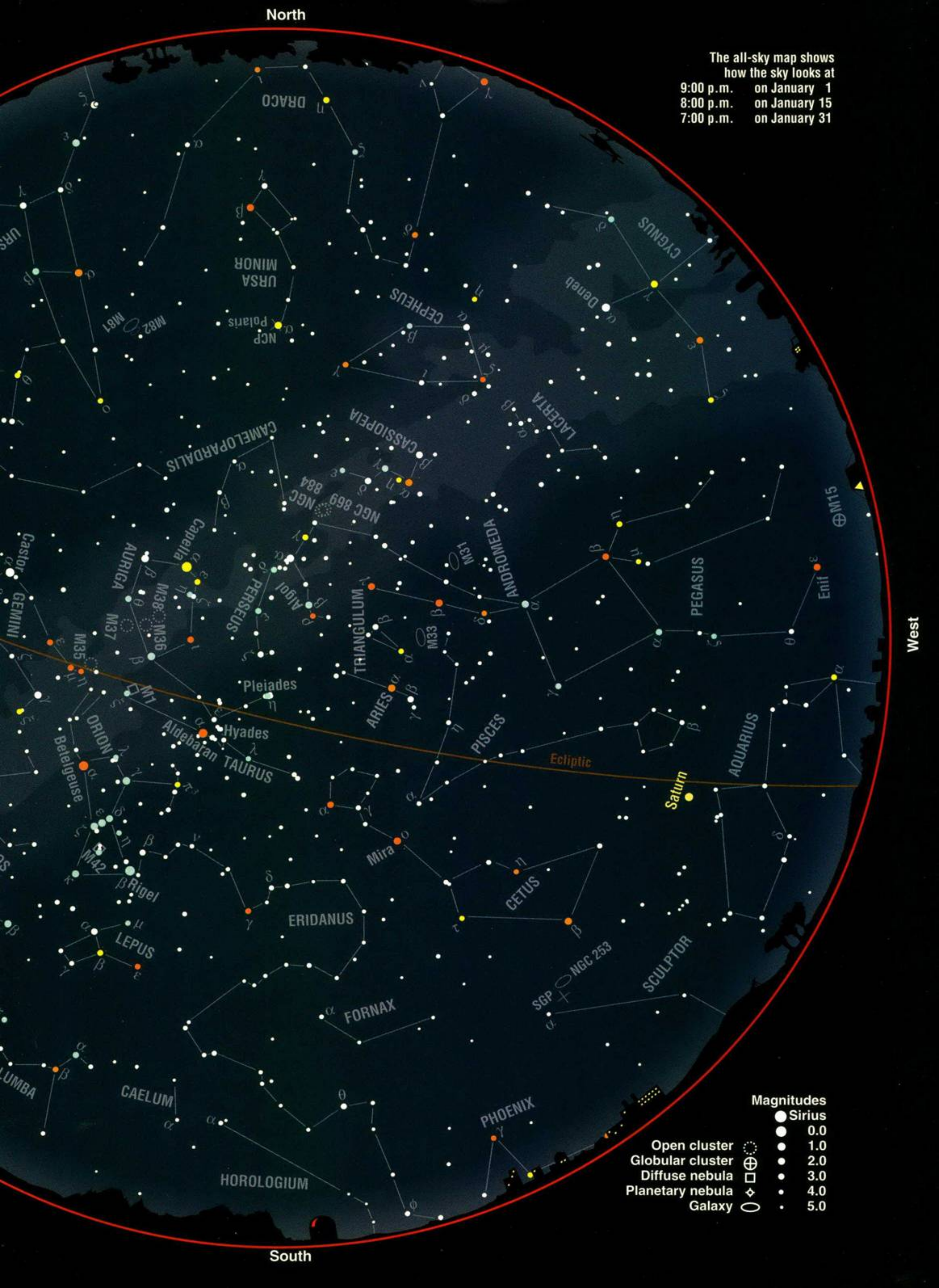
31 Asteroid Eleonora is at opposition



Sun.	Mon.	Tue.	Wed.	Thu.	Fri.	Sat.
	1	2	3	4	5	6
7	8	9	10	11	12	13
14	15	16	17	18	19	20
21	22	23	24	25	26	27
28	29	30	31			



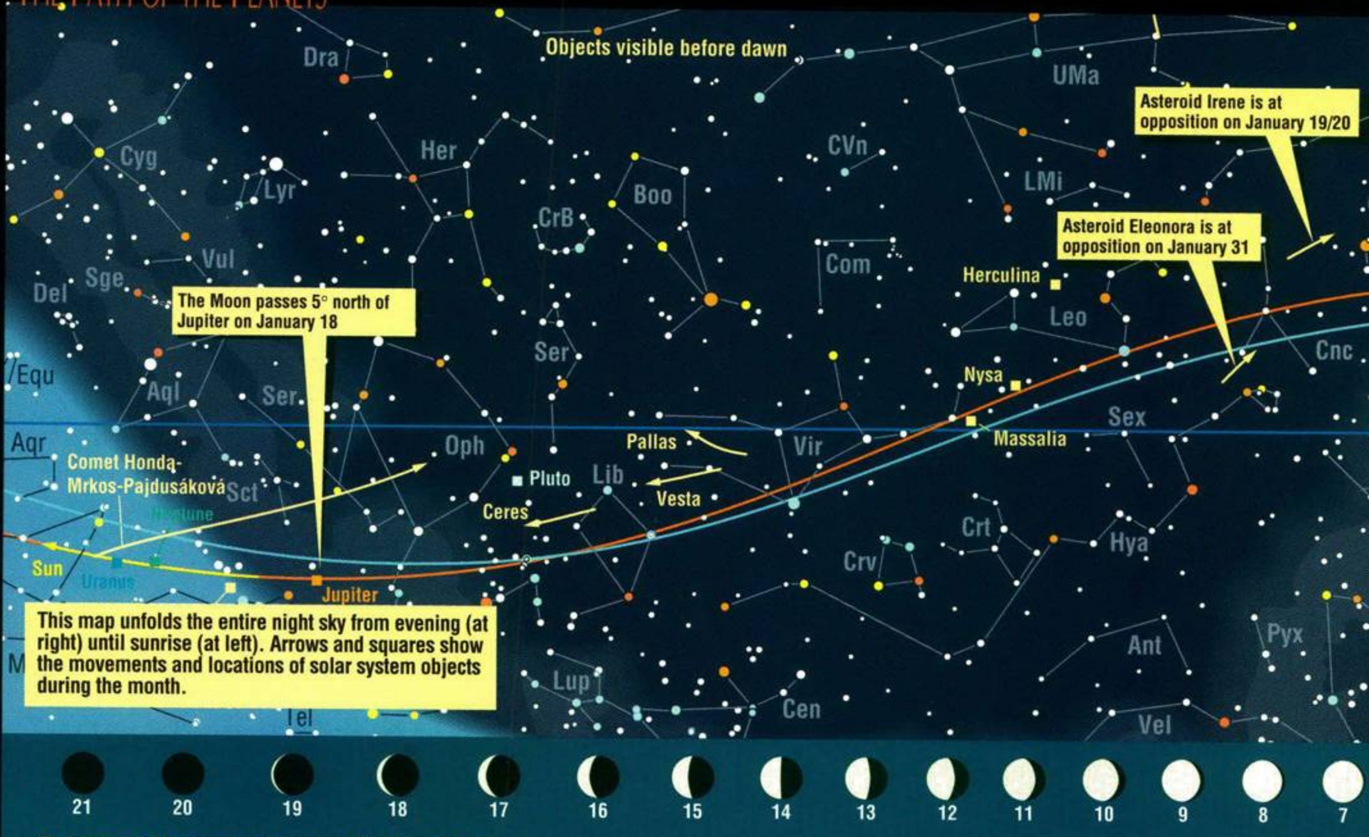
This map portrays the sky at times shown in the upper right corner of the page. Located just outside the map are the four directions: north, south, east, and west. To find stars above your horizon, hold the map overhead and orient it so a direction label matches the direction you're facing. The stars above the map's horizon now match what's in the sky.


North
DRACO
URSA MINOR
NCP
Polaris
M81
M82
CEPHEUS
CYGNUS
Deneb
LACERTA
CASSIOPEIA
CAMELOPARDALIS
NGC 869
NGC 884
Capella
AURIGA
Castor
GEMINI
PERSEUS
Algol
M38
M37
M36
M35
TRIANGULUM
M33
M31
ANDROMEDA
PEGASUS
Enif
M15
West
Pleiades
M1
ARIES
PISCES
AQUARIUS
Hyades
Aldebaran
TAURUS
ORION
Betelgeuse
Ecliptic
Saturn
Mira
M42
Rigel
CETUS
ERIDANUS
LEPUS
NGC 253
SCULPTOR
SGP
FORNAX
COLUMBA
CAELUM
PHOENIX
HOROLOGIUM
South
Magnitudes
Sirius
0.0
1.0
2.0
3.0
4.0
5.0
Open cluster
Globular cluster
Diffuse nebula
Planetary nebula
Galaxy

The all-sky map shows how the sky looks at

9:00 p.m. on January 1
8:00 p.m. on January 15
7:00 p.m. on January 31

THE PATH OF THE PLANETS


Objects visible before dawn
Dra
Cyg
Lyr
Her
Vul
Sge
Del
Equ
Aql
Ser
Aqr
Sct
Oph
CrB
Boo
Ser
CVn
Com
UMa
LMi
Herculina
Leo
Nysa
Massalia
Cnc
Sex
Vir
Pallas
Pluto
Lib
Vesta
Ceres
Neptune
Sun
Uranus
Jupiter
Crv
Crt
Hya
Ant
Pyx
Lup
Cen
Vel
Tel
M
21
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8
7

Comet Honda-Mrkos-Pajdusáková

The Moon passes 5° north of Jupiter on January 18

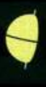
Asteroid Irene is at opposition on January 19/20

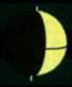
Asteroid Eleonora is at opposition on January 31

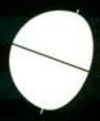
This map unfolds the entire night sky from evening (at right) until sunrise (at left). Arrows and squares show the movements and locations of solar system objects during the month.

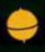
To locate the Moon in the sky, draw a line from the phase shown for the day straight up to the curved light-blue line.

PLANETS	MERCURY	MERCURY	VENUS	MARS	JUP
Date	January 1	January 31	January 15	January 15	Janu
Magnitude	–0.6	0.5	–4.0	1.2	–
Angular Size	6.5"	8.6"	13.4"	4.0"	32
Illumination	65%	32%	81%	100%	10
Distance (AU) from Earth	1.033	0.780	1.242	2.343	6.
Distance (AU) from Sun	0.342	0.385	0.725	1.391	5.
Right Ascension (2000.0)	20h06.6m	19h21.5m	22h10.0m	20h31.3m	18h
Declination (2000.0)	–21°41'	–19°26'	–13°03'	–20°02'	–23

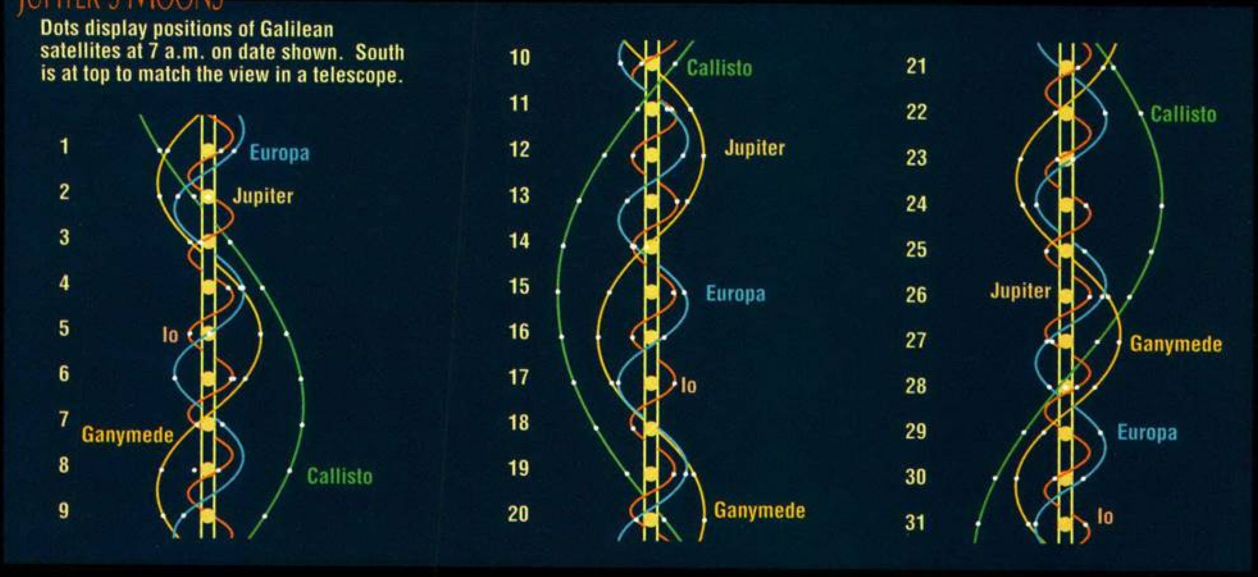




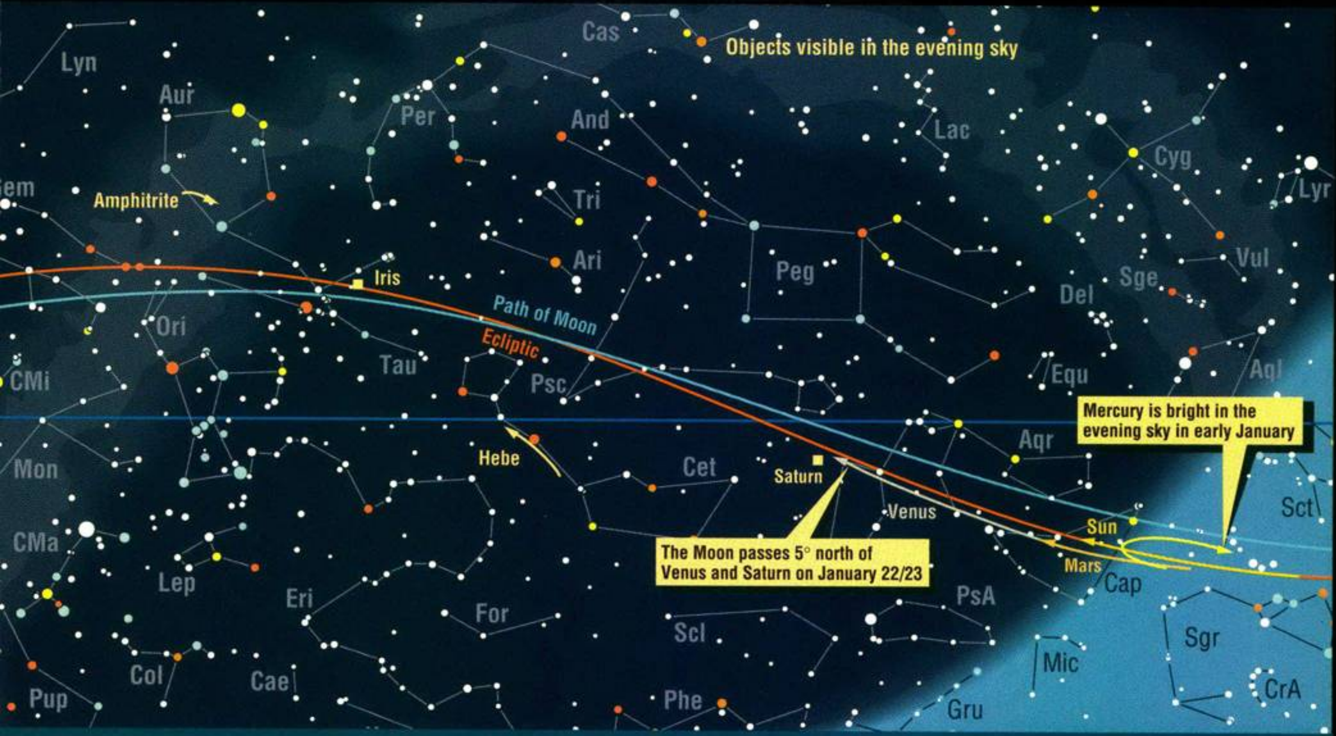




JUPITER'S MOONS



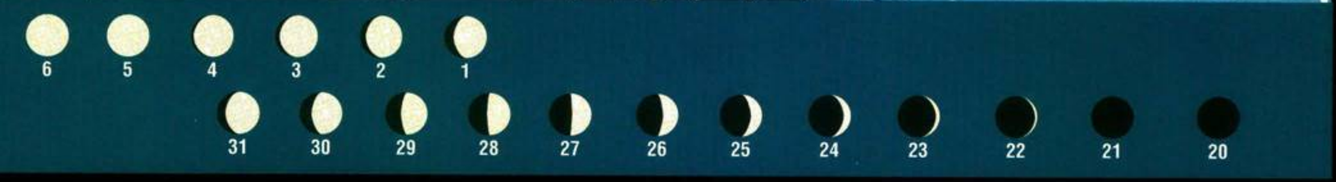
Dots display positions of Galilean satellites at 7 a.m. on date shown. South is at top to match the view in a telescope.


Lyn
Aur
Cas
Per
And
Lac
Cyg
Lyr
em
Amphitrite
Tri
Ari
Peg
Vul
Sge
Del
Iris
Path of Moon
Ecliptic
Ori
Tau
Psc
Equ
Agl
CMi
Aqr
Hebe
Cet
Saturn
Sct
Mon
Venus
Sun
Mars
Cap
CMa
Lep
Eri
For
PsA
Scl
Sgr
Mic
Col
Cae
Pup
Phe
Gru
CrA

Objects visible in the evening sky

Mercury is bright in the evening sky in early January

The Moon passes 5° north of Venus and Saturn on January 22/23


6
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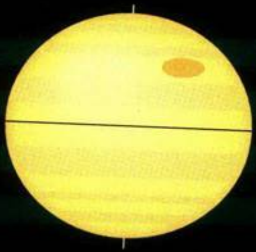
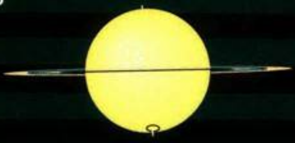
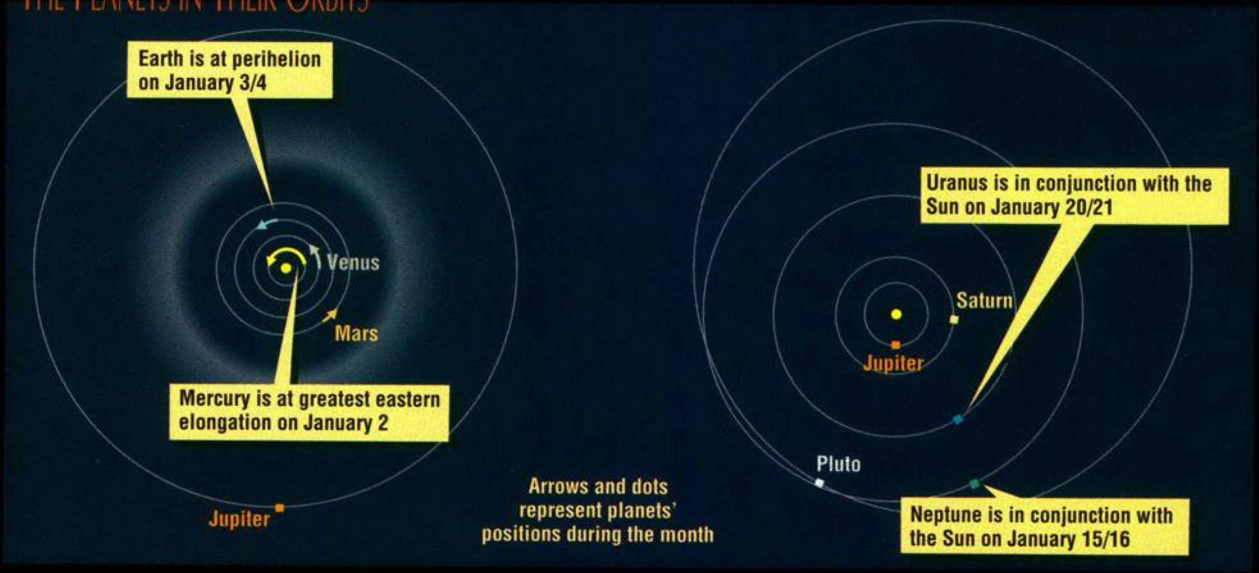




TER	SATURN	URANUS	NEPTUNE	PLUTO
ry 15	January 15	January 15	January 15	January 15
.8	1.2	5.9	8.0	13.8
.0"	16.5"	3.4"	2.2"	0.1"
0%	100%	100%	100%	100%
67	10.083	20.726	31.148	30.462
65	9.574	19.748	30.165	29.879
1.6m	23h28.5m	20h10.1m	19h48.5m	16h11.6m
°11'	−5°40'	−20°38'	−20°36'	−7°58'

THE PLANETS IN THEIR ORBITS


Venus
Mars
Jupiter
Saturn
Jupiter
Pluto

Earth is at perihelion on January 3/4

Mercury is at greatest eastern elongation on January 2

Arrows and dots represent planets' positions during the month

Uranus is in conjunction with the Sun on January 20/21

Neptune is in conjunction with the Sun on January 15/16 magnitude –0.7 from a distance of 74 light-years, and from my home in Austin, Texas, it resembles another Sirius. By that I mean it is also a brilliant star that makes a lower arc across the southern sky at nearly the same time as Sirius. Thus when Sirius is highest in the south, so is Canopus, glittering below Sirius, its magnificent brightness dimmed by the layers of air through which we must look.

The farther south you go, the higher Sirius and Canopus appear in the sky. From the Southern Hemisphere, as they shift to being nearly overhead, the two brilliant stars appear like twin beacons sweeping across the sky dome.

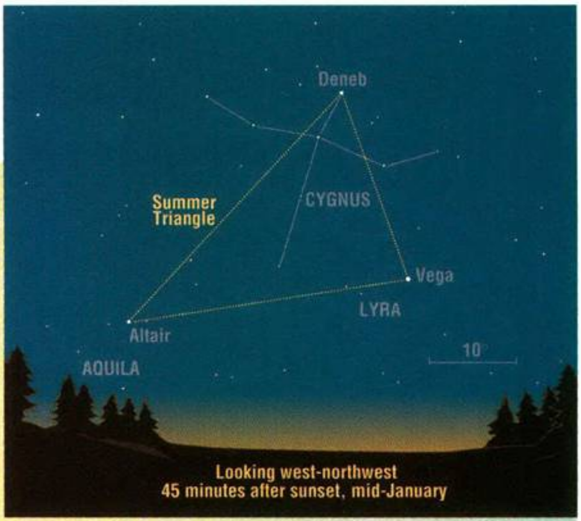
Along with Sirius and Canopus, other bright winter stars form some of the sky's most distinctive patterns. Try this experiment if you have yet to learn the constellations of winter: Make up your own shapes or asterisms and then take a star chart outside to see how closely your imagination matches that of the ancient constellation-makers.

Nestled far from winter's luminaries and low in the southwest shortly after sunset is **Saturn**, in the constellation Aquarius the Water Carrier. Saturn shines a golden color that has a steady quality to its light. A small telescope reveals Saturn as ringless, or nearly so.

Twice in each orbit of Saturn, or about every 15 years, we on Earth pass through the plane of Saturn's rings. At that time the rings — which are less than a mile thick — cannot be seen from Earth, and Saturn appears "ringless" even through telescopes. In 1987 Saturn's rings achieved a maximum tilt toward Earth of about 27°. Then the rings slowly began to close, so that by 1995 we witnessed another edge-on appearance.

When Earth passes through the plane of Saturn's rings, it does so either once or three times in less

First Views:
Summer Triangle's Winter Finale



Looking west-northwest
45 minutes after sunset, mid-January

No, the title is not a New Year's prank. As the color of evening twilight fades some 45 minutes after sunset, three bright stars, Altair, Vega, and Deneb, sparkle brightly in the west. During summer, the trio dominates the zenith, and have come to be called "The Summer Triangle."

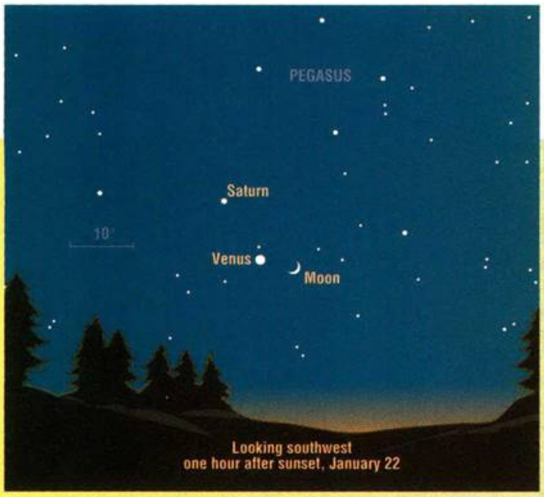
The Summer Triangle is not a classical constellation full of mythology, but a grouping of stars, an asterism, that's caught the eye of contemporary skywatchers. Nobody's sure who first coined the summertime signpost; it first appears in popular literature about a century ago. Since then it's been a harbinger of summer for spring skywatchers and a fond reminder of warm days gone by for the enduring stargazers of winter.

Vega forms the Triangle's brightest point, crowning the small constellation of Lyra the Harp. Vega is the brightest star in the northern half of the sky, and lies 25 light-years away

Along the horizon and far to the left of blue-white Vega is the bluish Altair, shining from a mere 16 light-years away. It forms the eye of Aquila the Eagle. At this time of year the mythological raptor is flying upwards, wings spread wide, as if trying to escape the cold grasp of winter.

Topmost in the triangle is Deneb, a luminary 1,500 light-years away that fulfills a dual role on the sky's stage. It marks the tail of Cygnus the Swan and crowns the top of another popular asterism, the Northern Cross. The cross stands almost upright above the northwestern horizon after sunset, while the Swan plunges head-first toward the horizon. — *A. L.*

The Moon Brushes Venus and Saturn



Looking southwest
one hour after sunset, January 22

January's second conjunction between the planets and the Moon happens on the evening of January 22, when the 60-hour-old Moon lies about 6° to the right of Venus. The vibrant color of twilight combines with the crescent Moon's earthshine to make for a reprise of the prior week's conjunction between the old Moon and Jupiter.

In this case, Venus is the blazing white beacon, shining at a stunning magnitude of –4. Low magnification through a telescope should readily show a deformed 14" disk that is 78 percent illuminated. Even the most cursory of glances will show that Venus does not display the same phase as the nearby Moon.

Saturn, in contrast, presents a completely different face. In January, we see only the unilluminated portion of the rings, which means that only the 16" ball of Saturn itself contributes to a comparatively meager brightness of magnitude 1.2.

On January 22 Saturn is more than 8 times farther away from us than Venus. The following evening, distinctly yellowish Saturn is a little more than 4° from the thickening crescent Moon. The Moon's encounter with both planets on each evening should be splendid in binoculars. Refer to the "Jupiter and the Moon Greet Dawn" project box on page 62 for tips on how to take pictures of this group. — *A. L.*

than a year, depending on the relative positions of Earth and Saturn in their orbits around the Sun.

Last year saw two ring-plane passages, the first in May and the second in August. Earth will pass through Saturn's ring-plane for the third time in less than a year next month, the last time in this century. If you haven't seen Saturn without its rings yet, February will be your last chance until the year 2009.

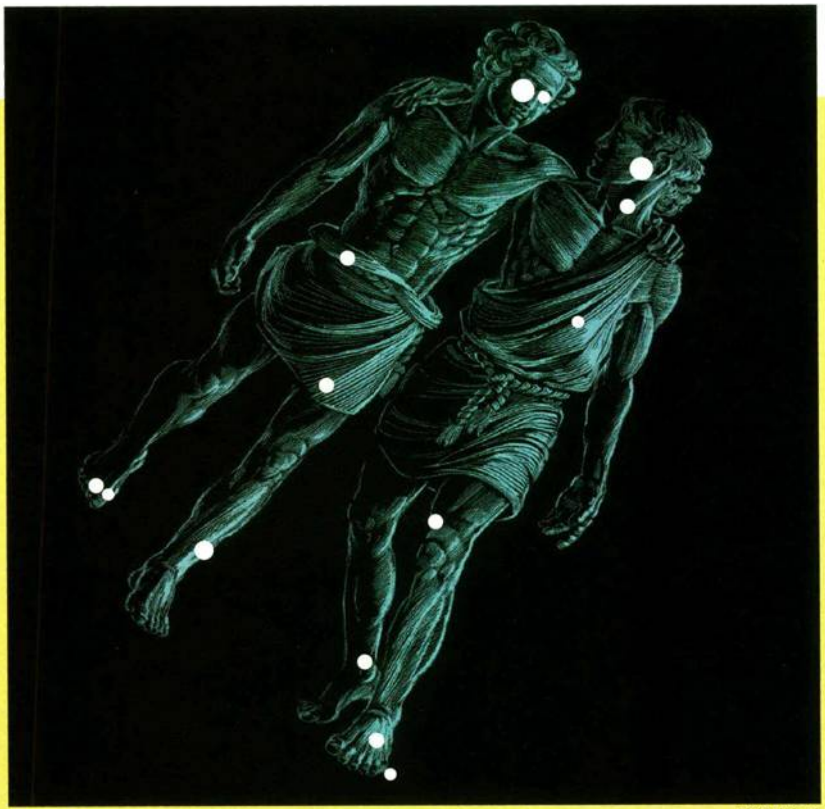
The virtually ringless Saturn shines at magnitude 1.2 as January opens. The planet's brightness sans rings almost seems lackluster when compared to previous years. But it is still the brightest "star" in this star-poor region of the sky. What's more, this month Venus creeps up from below Saturn so that by the end of January, you'll be able to pick out Saturn rather easily.

As the month begins, Saturn's brilliant partner **Venus** shines at magnitude –4.0. It can and will get brighter, but even now it outshines all other objects in the sky except for the Sun and Moon.

A telescope turned on Venus reveals a remote 12" disk that will become more interesting to look at as 1996 unfolds. Between now and June 10, when Venus passes between Earth and the Sun, the planet's phase will wane through gibbous to a thin crescent while its apparent size swells to almost 60".

This month, however, the planet looks like a smaller, more remote version of a waning gibbous Moon. Now's the time to start monitoring its wonderful metamorphosis.

The Starry Sky: Gemini


Keith Ward

Of the glittering array of bright stars overhead on winter evenings, two are noticeable for being near each other in the sky. Castor and Pollux mark the heads of the Twins in the constellation Gemini. They form the brightest close pair of stars seen from the Northern Hemisphere.

Pollux and Castor have been known as "twins" in many cultures. They are sometimes called the Dioscuri, or sons of Zeus, king of the gods. Their mother was the beautiful Leda, to whom Zeus appeared in the form of a swan. Pollux had an immortal soul; at his death, he was destined for a home on Mount Olympus. Castor was mortal.

Some said his father was not the mighty Zeus, but rather an earthly king called Tyndareus. Thus Castor, along with the rest of mankind, would have Hades' underworld as his final resting place. This underworld was not considered a place of punishment, by the way, but a place of unremitting dullness.

Castor excelled at horsemanship, while Pollux was skilled at boxing and fighting battles. They were said to be as alike as two twins could be. Both married the beautiful daughters of a king of Sparta.

A sad day came when, during a brawl, a spear pierced Castor's heart. Realizing that his brother would now have to dwell forever in Hades, Pollux prayed to Zeus to be sent to the underworld with his brother. Zeus was not able to grant his wish, but he told Pollux that he and Castor could spend half their time on Mount Olympus and the other half in the world of the dead. Also, they would be given a place in the sky as the constellation Gemini.

The Blackfoot Indians use this same star pattern to tell of two infants whose mother was killed by a wandering medicine man. The medicine man placed one infant by the ashes of the fire in the tipi. He gave that child the name Ashes-Chief.

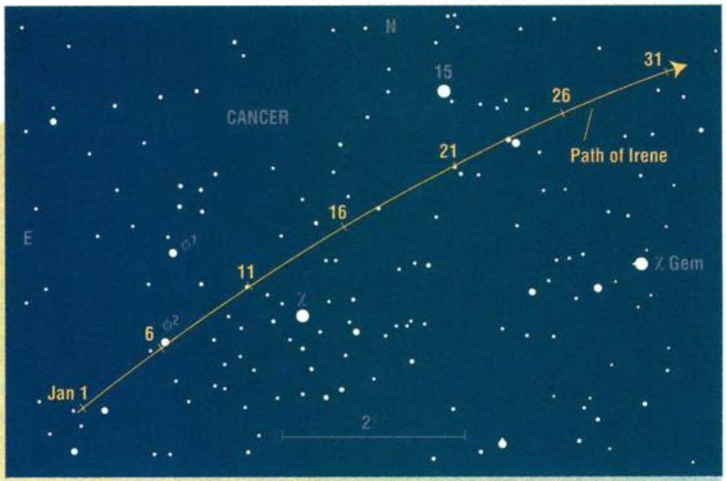
The other infant was placed behind a buffalo skin and so became known as Stuck-Behind. They had magical powers when they grew to manhood. When they died, they rose into the sky as the Twins.

The Chinese tied Castor and Pollux to the two primary mystical elements of the universe. These stars were said to represent Yin and Yang, the embodiment of opposites at work in the world: day and night, light and dark, good and bad. Yin is said to be female, while Yang is male. Yin represents shadow, and Yang light. Yin is winter, and Yang is summer, and so on. In this philosophy, neither element has meaning without the other.

In our world of western science, the two stars Castor and Pollux have no relationship to each other, except their proximity along our line of sight. At 46 light-years away, Castor is 11 light-years more distant than Pollux, the brighter of the two stars at magnitude 1.1, and shines with a golden color.

Meanwhile Castor, although fainter than Pollux at magnitude 1.6, is one of the sky's most fascinating stars. Telescopes reveal three visible components in the Castor system. Each of these in turn is a spectroscopic binary, meaning the single point of light we call Castor is really composed of six stars. — *Deborah Byrd*

Follow Asteroid Irene through Cancer



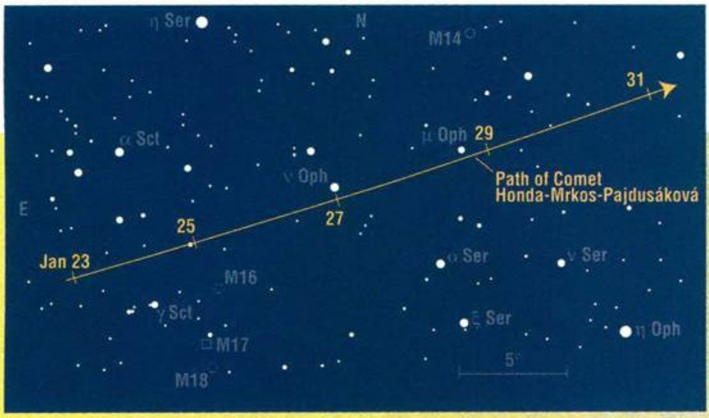
From time to time in solar system observing, you can almost watch objects move in real time. This happens during January when a 158-km-wide rock called 14 Irene slides through the stellar backdrop of Cancer the Crab.

On two nights in particular, January 6 and 24, look for it near some bright stars. The accompanying table shows the asteroid's position at 11 p.m. EST, 8 p.m. PST. To find the interloper, make a drawing of the asteroid's area in a telescope's field of view. A night or two later, go back and see which 10th magnitude "star" has moved. This slow motion betrays Irene's identity. If you're ambitious and possess a keen eye (not to mention luck with winter weather) you might detect Irene's subtle movement over the space of an hour or two.

The British astronomer J. R. Hind used this technique to discover Irene on May 19, 1851. It was the 14th such object found in an area of the solar system where astronomers were looking for a planet between Mars and Jupiter. Hind named his discovery for the Roman goddess Irene, the personification of peace and daughter of Jupiter and Themis. — *A. L.*

COORDINATES FOR IRENE

Date	**R.A. (2000)**	**Dec.**
January 1	8h30.8m	26°11'
January 6	8h27.0m	26°52'
January 11	8h22.6m	27°33'
January 16	8h17.7m	28°12'
January 21	8h12.6m	28°50'
January 26	8h07.4m	29°24'
January 31	8h02.2m	29°54'



Find Comet Honda-Mrkos-Pajdusóková

Late January sees Periodic Comet Honda-Mrkos-Pajdusóková put on a show for telescopic and binocular viewers as it cuts inside Earth's orbit to glow at a respectable 7th magnitude. Peak visibility happens in the southeast during the last week of January as the comet slices through Scutum and into Ophiuchus in the predawn sky. During that time, Comet H-M-P covers almost 3° of sky per day.

The table to the right betrays H-M-P's motion through the sky. It shows the comet's position at 5 a.m. EST, 2 a.m. PST. Use binoculars to start looking for Comet H-M-P in the southeast well before morning twilight, more than an hour before sunrise. Observe from a horizon free of obstructions. The comet should appear as a faint, gray fuzzball that's brighter toward its center. If you're observing from the city, it will appear as a slightly fuzzy point of light.

As it continues to climb higher through the summer Milky Way, the comet brushes some notable binocular signposts. It lies within three degrees of the popular open cluster and emission nebula M16 on the morning of January 25. Comet H-M-P brushes just south of 3.3 magnitude Mu (μ) Ophiuchi and 4.6 magnitude Nu (ν) Ophiuchi on January 27 and 29, respectively. At month's end, the rapidly fading (and receding) comet closes in on globular cluster M10.

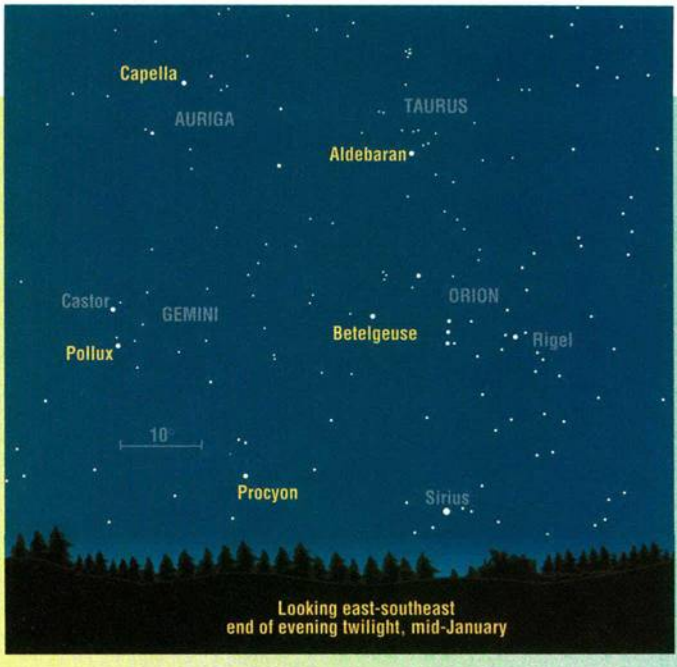
Comet Honda-Mrkos-Pajdusóková orbits the Sun every 5.27 years and draws close to the Sun at half the Earth-Sun distance. The dirty celestial snowball's closest approach has been witnessed since its discovery on December 3, 1948.

When looking at this faint comet, it helps to comprehend the nature of what you are witnessing. The solid portion of Comet H-M-P, its nucleus, is probably only a few miles across, while its coma, the comet's glowing gaseous shroud, has a diameter of several thousand miles. — *A. L.*

COORDINATES FOR COMET HONDA-MRKOS-PAJDUSÓKOVÁ

Date	**R.A. (2000)**	**Dec.**
January 23	18h43.3m	–13°22'
January 25	18h22.2m	–11°55'
January 27	17h58.9m	–10°10'
January 29	17h33.5m	–08°08'
January 31	17h06.4m	–05°49'

Betelgeuse the Variable



Looking east-southeast
end of evening twilight, mid-January

Believe it or not, Betelgeuse, the bright red star that marks Orion's right shoulder, is a giant variable star. In winter almost all stars twinkle and vary in brightness, an effect of Earth's churning and roiling atmosphere. But like many of its red giant cousins, Betelgeuse actually varies in brightness.

The catch is that Betelgeuse fluctuates between magnitude 0.4 and 1.3 very slowly over 2,335 days, the mark of a semiregular variable. Interspersed with this very long period are several shorter fluctuations that fall irregularly between a few tenths of a magnitude for many months.

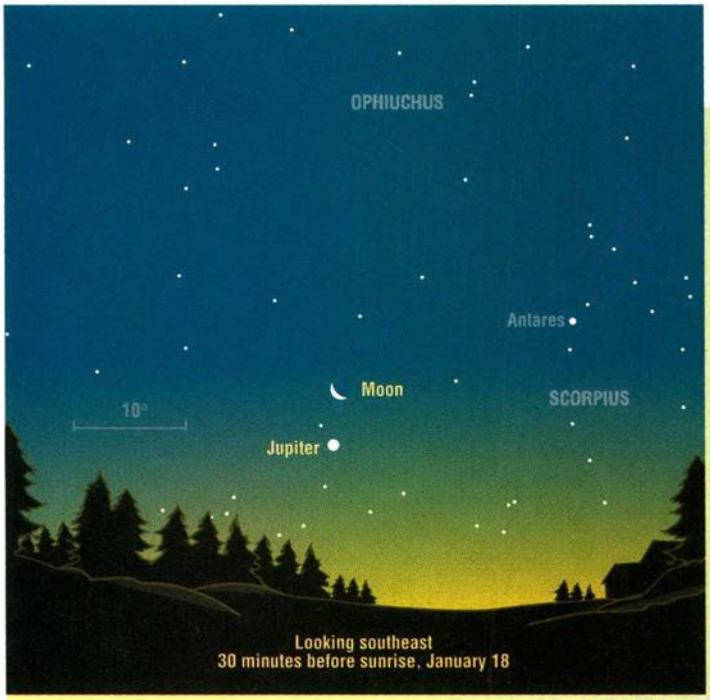
The brightest Betelgeuse has been in recent years was in December 1994, when observers measured it at magnitude 0.6. As of May 1995, Betelgeuse had dimmed to magnitude 0.9, only two-tenths of a magnitude from its faintest value set over the past 30 years, when it shined at magnitude 1.1 in the early '80s.

Although it's easy and fun to monitor Betelgeuse's subtle variations, it helps to have patience. Use nearby stars Procyon (magnitude 0.38), Pollux (1.14), Aldebaran (0.85), and Capella (0.08) as benchmarks to help you monitor its slow pulse.

Every couple of weeks, note whether Betelgeuse is brighter, fainter, or somewhere in between these stars. Compare its brightness to stars similar in elevation above the horizon so that haze does not affect your impressions.

If you'd like to get involved in a long-term program that tracks the brightness of Betelgeuse and other variable stars, write the American Association of Variable Star Observers, 25 Birch St., Cambridge, MA 02138-1205 or e-mail them at aavso@aavso.org.

The AAVSO compiles amateur observations of variable stars into data bases that can be used by professional astronomers. — *A. L.*



Looking southeast
30 minutes before sunrise, January 18

Jupiter and the Moon Greet Dawn

Early morning twilight is a special time. Dawn's colors seem more electric than the evening's, while the air is both crisper and quieter.

Another reason to appreciate dawn happens on the morning of January 18; about 30 minutes before sunrise a striking crescent Moon joins brilliant Jupiter above the southeastern horizon.

Because the Moon is about 48 hours from its new phase, there will be plenty of earthshine to see, which is sunlight reflected off Earth's clouds and oceans onto the shadowed portion of the Moon's face.

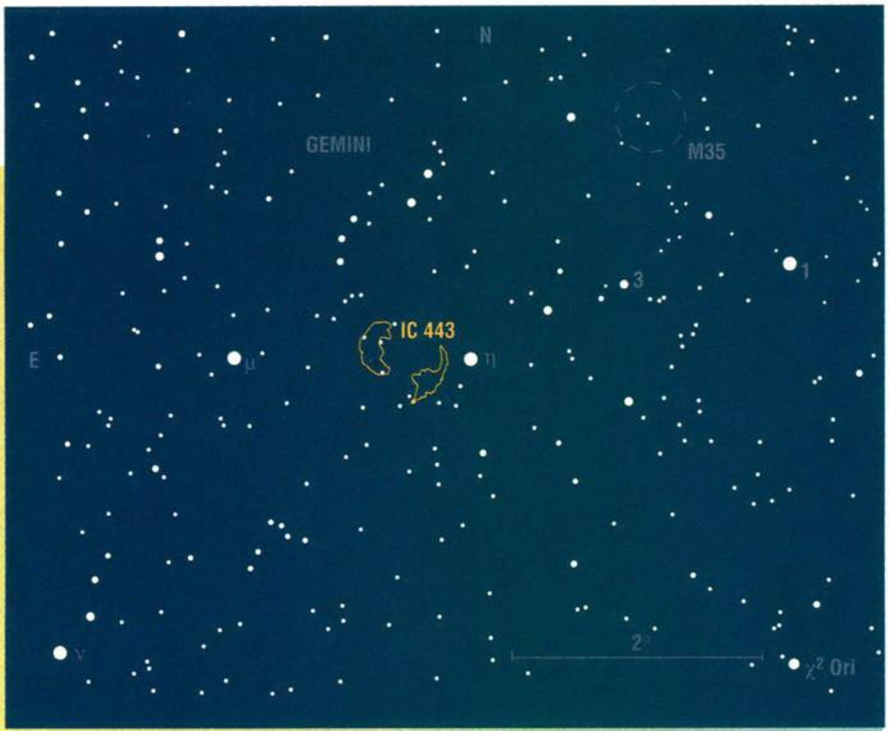
It's very easy to get great pictures of this conjunction. Load your camera with ISO 100 or faster film and place it on a tripod. Focus the lens to infinity, set the shutter speed to "bulb," and screw in a cable release to fire the camera. With the lens set to around f/2.8 expose between 1/15 and 2 seconds to capture earthshine mingled with the colors of twilight.

Try a variety of exposures and lens settings to strike a balance between earthshine and sky color. Experiment and enjoy — and don't forget to look with binoculars.

Incidentally, on the same morning the southeastern United States sees the Moon skim the open cluster M23 in Sagittarius. — *A. L.*

Observer's Challenge:

Supernova Remnant IC 443



Supernova remnants are among the deep-sky's most intriguing denizens. Many thousands of years ago a massive star died and blasted its outer layers of gas deep into space. Today, we can see one such expanding shell of gas in southern Gemini, called IC 443.

This object is easy to locate with a scope but, like most faint nebulae, tough to see. On a dark, transparent night from a site far away from city lights, IC 443 looks like a ghostly cloud of gas about 1° east-northeast of Eta (η) Geminorum, the star most people use to hop to the bright star cluster M35.

The difficulty in observing IC 443 is that it is almost invisible. But thanks to the magic of nebula filters, it is visible in telescopes with mirrors as small as 8 inches. Your best bet is to use a high-contrast UHC or O III nebula filter threaded into an eyepiece working at between 50 and 80 power. To block out extraneous light (even sky glow), consider cloaking your head at the eyepiece with a dark cloth.

IC 443's shape is vaguely reminiscent of another supernova remnant that's a favorite among deep-sky observers: the Crescent Nebula (NGC 6888) in Cygnus. In fact, some even refer to IC 443 as "The Crescent's Ghost," because it bears much resemblance to its brighter cousin in Cygnus.

Overall, IC 443 is a 50' by 40' arc of light with an integrated magnitude of 8.8 that lies at RA = 6h17m, Dec. = 22°47' (epoch 2000). Record the detail you glimpse by making a sketch that includes field stars as markers and then compare it to details on the finder diagram above. On excellent nights, scopes 16 inches or larger will be required if you want to detect subtle filamentary structure in the Crescent's Ghost. If you have trouble seeing the Crescent's Ghost, try again on a darker night. The sky's darkness is often the key to visibility, more so than the size of scope.

Photographs reveal IC 443 to be the brightest section of a gas bubble. I have never heard of anyone spotting the remnant's fainter lobe, located between Eta and brighter IC 443. Some nebular knots should be within the reach of many backyard scopes; perhaps the nearby glare of Eta creates a contrast problem. — *A. L.*

Look for Venus and Saturn near January's young crescent Moon on the evening of the 21st, one night after New Moon. That night a line connecting the fragile crescent with Venus and Saturn betrays the whereabouts of the ecliptic, the path of the Sun, Moon, and planets.

From our vantage point in the Northern Hemisphere, the ecliptic is beginning to tip up with respect to the western horizon. It will continue to do so through spring. On January 22, the Moon appears next to Venus; by the following evening, it pairs up with Saturn.

There's yet another planet in the west after sunset: **Mercury**, the innermost world in the Sun's family. Mercury starts the month low in the southwest after sunset, far lower in the sky than Venus or Saturn. At greatest elongation on January 2, it is 19° east of the Sun and placed barely 6° above the horizon 45 minutes after sunset. Although its magnitude of –0.6 is very bright, the tiny planet lies deep in evening twilight. Use binoculars to look for it no later than an hour after sunset.

Once you find Mercury, turn your telescope in its direction. The planet wanes dramatically in phase this month before passing between Earth and the Sun on January 18. Thereafter Mercury returns to the predawn sky, where a telescope reveals a waxing phase. Look for Mercury low in the eastern predawn sky during the last days of January, half an hour before sunup.

Mars, Uranus, and Neptune are all traveling behind the Sun this month. **Neptune** has its conjunction with the Sun on January 16, while **Uranus** falls in close behind on January 21. Both planets reappear in the predawn sky in February.

Mars travels around the Sun at a speed that is not much slower than Earth. As a result, it will be out of sight much longer. Its conjunction occurs in March, and it will return to the predawn sky in May.

In early January, **Jupiter** rises too close to the Sun to be easily seen in morning twilight. As the days pass, it rises earlier and comes into view as a brilliant object low in the eastern predawn sky.

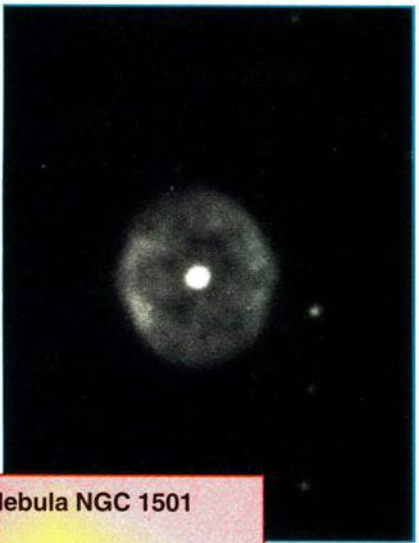
Look for Jupiter on January 18, when it is near the old crescent Moon in front of the constellation Sagittarius. It shines at magnitude –1.8 and reveals to telescopic observers a 32-inch-diameter disk, along with orbiting moons. You'll have much better views of Jupiter when it gets higher above dawn's light this spring and summer. □

Deborah Byrd writes and produces the daily "Earth and Sky" radio series. Alister Ling is a meteorologist with Environment Canada.

A Trip Through the Wasteland

Scouting through plain-Jane constellations like Camelopardalis and Lynx reveals distant galaxies and faraway clusters of stars.

by Lee T. Macdonald



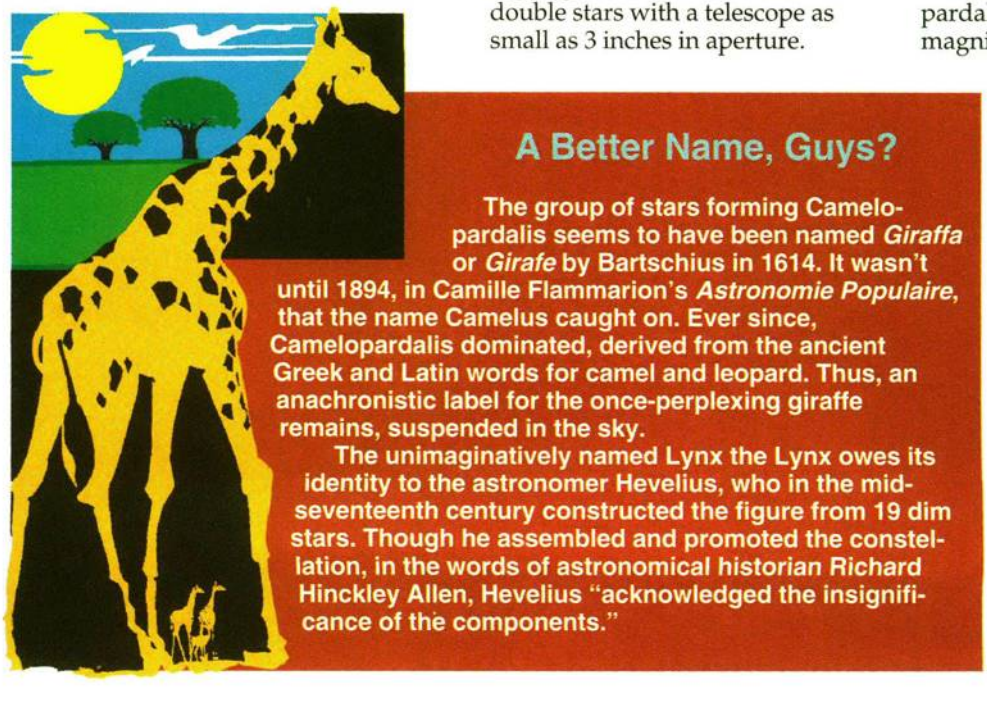
Planetary Nebula NGC 1501

by Kim Zussman (modified 11-inch SCT at f/10, hypersensitized Tech Pan film, 70-minute exposure)

Stand outside and look up on a January or February evening. Go do it. You may not know it, but part of your view contains a rather blank area of sky bordered by Auriga and Gemini to the south and Ursa Major to the east. It looks like a celestial wasteland.

This area comprises the constellations Camelopardalis the Giraffe and Lynx the Lynx (catchy name, huh?). Although you may think the prospects of seeing anything in such a dull-looking region of sky are slim at best, they're not.

Camelopardalis and Lynx may not be constructed of bright, glittering stars, but they hold a few diamonds in the rough that make for several fine evenings of observing of galaxies, star clusters, and double stars with a telescope as small as 3 inches in aperture.



A Better Name, Guys?

The group of stars forming Camelopardalis seems to have been named *Giraffa* or *Girafe* by Bartschius in 1614. It wasn't until 1894, in Camille Flammarion's *Astronomie Populaire*, that the name Camelus caught on. Ever since, Camelopardalis dominated, derived from the ancient Greek and Latin words for camel and leopard. Thus, an anachronistic label for the once-perplexing giraffe remains, suspended in the sky.

The unimaginatively named Lynx the Lynx owes its identity to the astronomer Hevelius, who in the mid-seventeenth century constructed the figure from 19 dim stars. Though he assembled and promoted the constellation, in the words of astronomical historian Richard Hinckley Allen, Hevelius "acknowledged the insignificance of the components."

Surprised by a Giraffe?

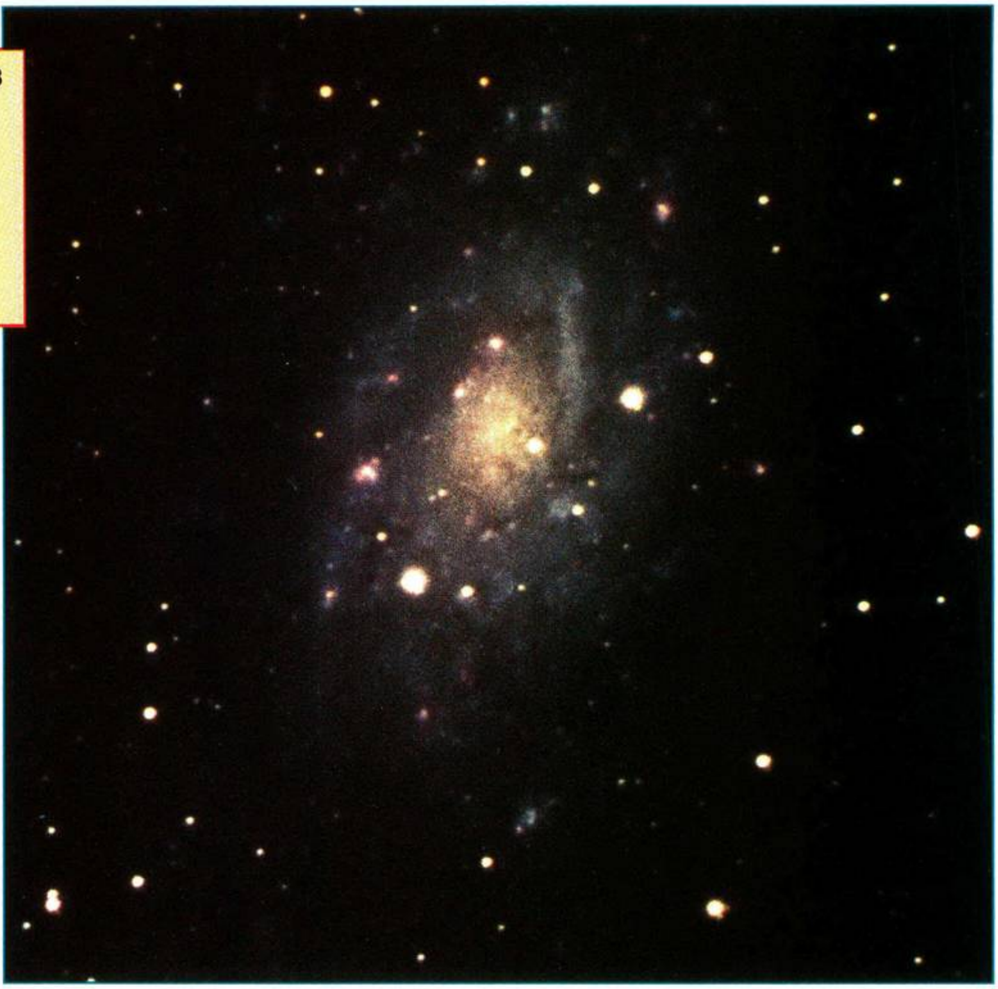
Usually, being surprised by a giraffe means bearing witness to some unforeseen natural act at the zoo and having to explain it to the kids. But you can be surprised by Camelopardalis, as well. It lies near the north celestial pole and is visible year-round for observers at mid-northern latitudes.

The constellation contains some interesting galaxies, a planetary nebula, and a double star. Start with the showpiece, spiral galaxy **NGC 2403** (mag. 8.4, size 17.8' by 11.0'), a little difficult to locate in the constellation's southeast corner but worth seeking out.

Find it by moving the telescope 5° southeast from the 5th-magnitude stars 42 and 43 Camelopardalis, in a line toward 3rd-magnitude Omicron (o) Ursae Majoris. Visible as a hazy spot in binoculars on dark nights, NGC 2403 may appear in telescopes like an elliptical reflection nebula.

An 8-inch scope shows a bright elliptical haze surrounded by a faint outer halo. Telescopes larger than 10 inches show mottled detail, the effect of dust scattered throughout the spiral arms.

Moving to western Camelopardalis brings you to **NGC 1502** (mag. 5.7, size 8'), a small, bright open cluster some 7° northwest of Beta (β)



Knotty Galaxy NGC 2403

by George Greaney and Mike Newton (14-inch SCT at f/7, Fuji Super HG 400 film, composite of two 50-minute exposures)

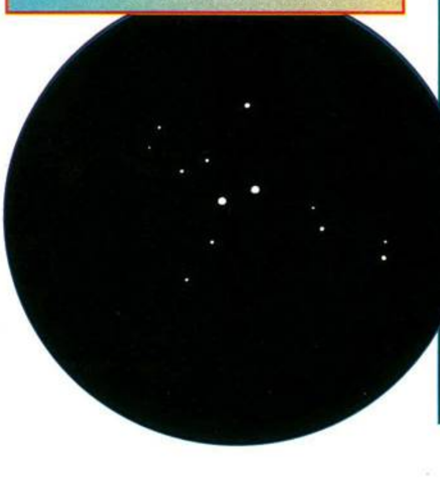
Camelopardalis. This cluster's 45 stars glow at 7th magnitude and fainter, and include a bright, easy double star, S485. On the cluster's edge you'll see the bright variable star SZ Camelopardalis. Just 1½° south of the cluster, you'll find **NGC 1501** (mag. 13.3_p, size 52"), a ghostly planetary nebula with a 14th-magnitude central star. On dark nights it appears as a pale disk, making it a challenge for small scopes.

Six degrees north and 1½° west of NGC 1502 is the dusty spiral galaxy **IC 342** (mag. 9.1_B, size 17.8' by 17.4'). Though it is rather close to our home galaxy, some 10 million light-years away, this object has a low surface brightness and is obscured by dust in our galaxy. Thus, it challenges small telescopes, which reveal it as a silvery spot of light with a slightly brighter center.

Moving north toward Polaris, the North Star, carries you to the galaxy **NGC 2146** (mag. 10.5, size 6.0' by 3.8'), a distorted barred spiral with a dusty disk. The galaxy appears as an elongated blur in any small telescope. Also, check out **NGC 2336** (mag. 10.5, size 6.9' by 4.0'), a galaxy 3½° northeast of NGC 2146. This spiral is characterized by tightly-wound arms and a bright center. Small telescopes

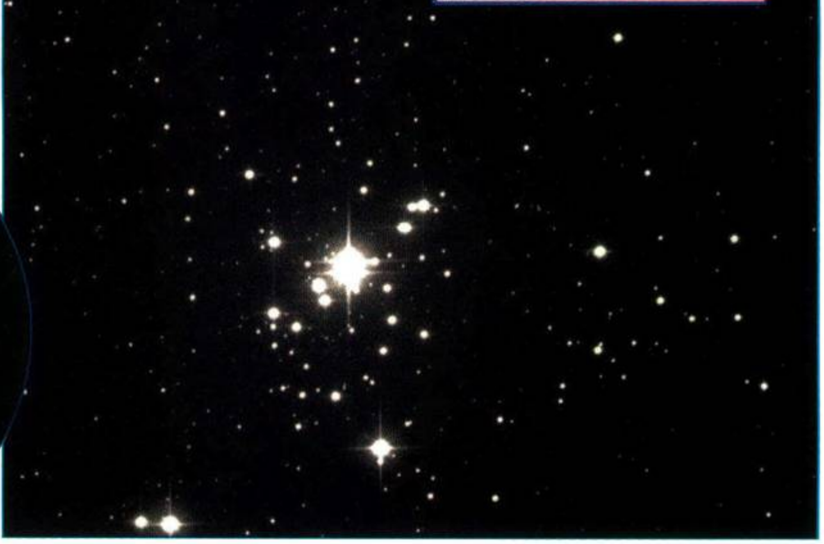
Open Cluster NGC 1502

Sketch by Lee T. Macdonald (8.5-inch reflector at 130x)



NGC 1502's Clump of Stars

by Preston Scott Justis (10-inch f/6 reflector, hypersensitized Tech Pan film, 60-minute exposure)



Distorted Galaxy NGC 2146

by Preston Scott Justis
(10-inch f/6 reflector, 103a-O film, 70-minute exposure)

How to Find It

These star atlases will give you a good grip on finding the objects in Camelopardalis, Lynx, and many other star groups:

Cambridge Star Atlas 2000.0 **by Wil Tirion (Cambridge University Press, New York, 1992). Beginning.**

Sky Atlas 2000.0 **by Wil Tirion (Sky Publishing Corp. and Cambridge University Press, Cambridge, Massachusetts, 1981). Intermediate.**

The Universe from Your Backyard **by David J. Eicher (Cambridge University Press, New York, 1988). Beginning.**

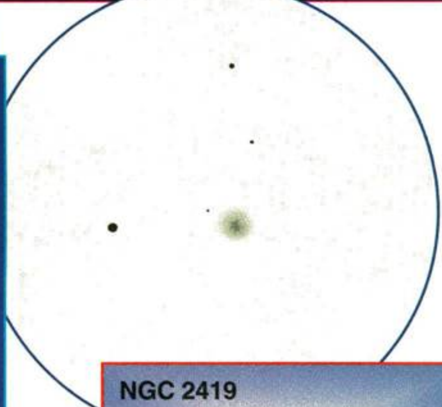
Uranometria 2000.0 **by Wil Tirion, Barry Rappaport, and George Lovi (Willmann-Bell, Richmond, 1987-1988). Advanced.**

NGC 2419

by Preston Scott Justis
(10-inch f/6 reflector, hypersensitized Tech Pan film, 90-minute exposure)

Galactic Houdini?

NGC 2419's immense distant of 300,000 light-years puts it on the fringe of our galaxy; years ago astronomer Harlow Shapley dubbed it the "Intergalactic Tramp" and believed it may escape the Galaxy's gravitational grip.



NGC 2419

Sketch by Lee T. Macdonald
(8.5-inch reflector at 130x)

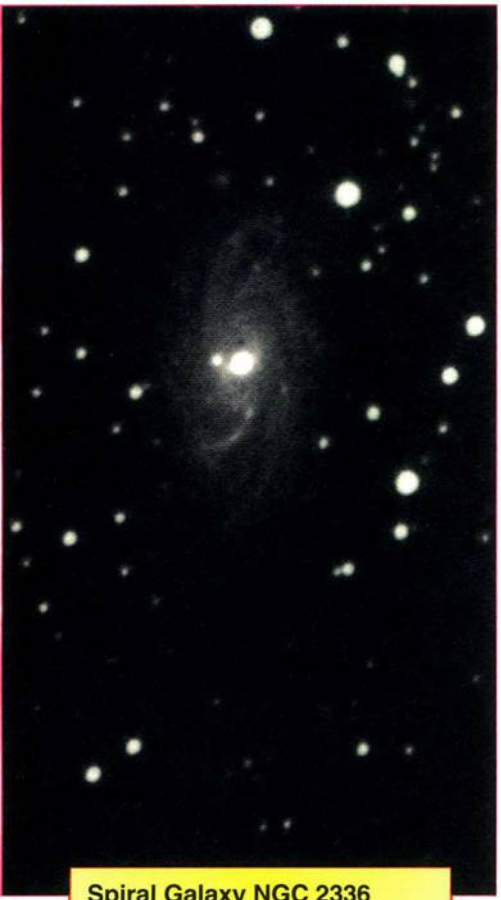
show a faint haze surrounding a bright core.

Hidden Treasures of the Lynx

Having explored the hidden gems of the Giraffe, move on to Lynx, a long, stretched constellation wedged between Auriga and Ursa Major. Lynx contains a number of pretty double stars. At the western end of Lynx, not far from the border with Camelopardalis, we find **12 Lyncis**, a superb quadruple star. Low power shows a 5th-magnitude star and its 7th-magnitude companion 8.7" away (p.a. 308°). However, if you increase magnification, you'll see that the brighter companion is itself a double. The magnitude 5.4 and 6.0 stars are separated by only 1.8", making the pair difficult with small scopes on less-than-perfect nights. A magnitude 10.6 star, the fourth, lies 170" away in p.a. 256°.

Less than 2° southeast of 12 Lyncis is the brighter quadruple star **15 Lyncis**, a challenge for 6-inch scopes. The two brightest stars are only 0.9" apart (p.a. 33°) and shine at magnitudes 4.8 and 5.9. The other stars glow at magnitudes 12.4 (29", 346°) and 8.9 (197", 167°).

Yet another quadruple star may be found in **19 Lyncis**, 4½° southeast of 15 Lyncis. The two brightest stars, at magnitudes 5.6 and 6.5, are separated by 14.8" (p.a. 315°), making both easy to see in any telescope. The third star, a 9th-magnitude sun, lies 215" away in p.a. 3°, and the fourth star, an

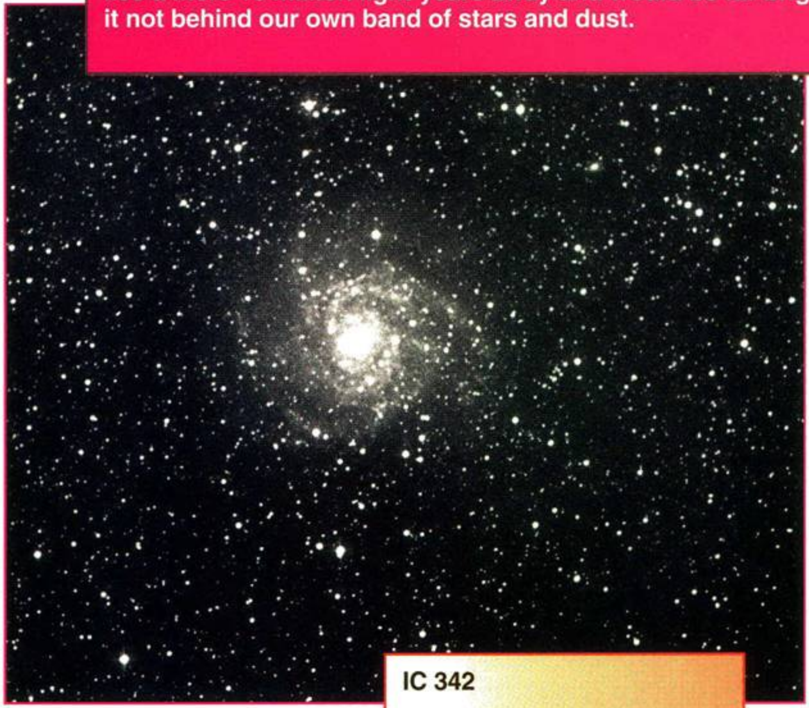


Spiral Galaxy NGC 2336

by Martin C. Germano
(8-inch f/5 reflector, hypersensitized Tech Pan film, 75-minute exposure)

A Hidden Giant

Obscured heavily by our Milky Way, the big face-on spiral IC 342 lies a mere 10 million light-years away and would be far brighter were it not behind our own band of stars and dust.



IC 342

by Martin C. Germano
(8-inch f/5 reflector, hypersensitized Tech Pan film, 90-minute exposure)

11th-magnitude object, is 74.2" away in p.a. 287°.

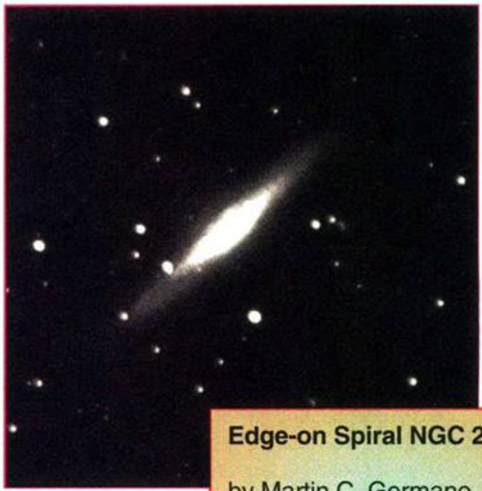
Lynx contains a number of galaxies, the brightest being **NGC 2683** (mag. 9.7, size 9.3' by 2.5'), a beautiful edge-on spiral. To find it, move 5° north-northeast of Iota (ι) Cancri. On a dark night, the galaxy shows an elongated haze surrounding a relatively large, cigar-shaped core. NGC 2683 has a high surface brightness, so its image can stand considerably high magnification.

The constellation's highlight is stuck in the western end of Lynx about 7° north of the brilliant star Castor in Gemini. Globular star cluster **NGC 2419** (mag. 10.4, size 4.1') lies a whopping 300,000 light-years away, making it the fifth most distant globular cluster known. The cluster's luminosity equals 560,000 Suns, making it bright enough for binocular viewing.

On a dark night, a 6-inch telescope shows the cluster as a 3'-diameter fuzzy disk with a strong central concentration. Don't expect to resolve individual stars in so distant a cluster except with the largest backyard telescopes — the group's brightest members glow at only 17th magnitude.

This seemingly blank area of sky offers a multitude of sights for skygazers during the long, cold nights of January and February.

Once you have observed these objects, try looking for some of the less obvious targets strewn across your star atlas.The Lynx and the Giraffe offer something for every telescope. □



Edge-on Spiral NGC 2683

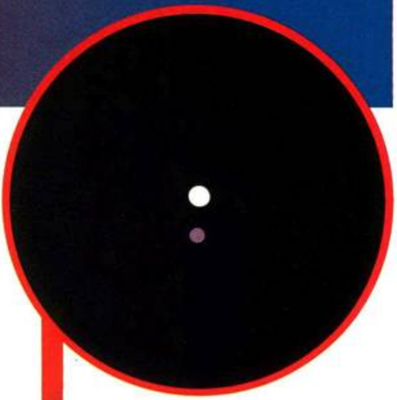
by Martin C. Germano
(8-inch f/5 reflector, hypersensitized Tech Pan film, 65-minute exposure)

Lee T. Macdonald is an avid observer who enjoys sketching deep-sky objects from Berkshire, England.

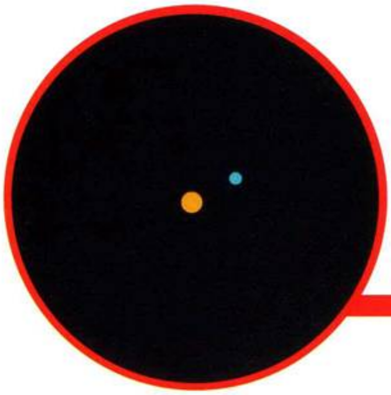
Touring Winter's Best Double Stars

Set aside a midwinter's evening to meet some undiscovered wonders nestled against the velvety black backdrop of space.

Story and eyepiece renderings
by Mark T. Stauffer



Delta (δ) Orionis
105x
3-inch f/11 refractor
R.A.: 5h32.0m
Dec.: 0°18.0'
Sep.: 52.6"
Mags.: 2.2, 6.3



Phi (ϕ) Tauri
105x
3-inch f/11 refractor
R.A.: 4h20.4m
Dec.: 27°21'
Sep.: 57"
Mags.: 5.0, 8.4

It just plain feels right to observe double stars in January. A winter evening's clear, bracing polar air accentuates the crisp, clean colors many doubles offer. These gems are often overlooked by observers who go for showier winter game, such as nebulae and open clusters. But a double's vivid hue and stunning arrangement will warm the heart of any observer, veteran or novice. To get you started in (or help you rediscover) the joys of double star observing, I've created this tour that runs from dusk to dawn. We'll start in the evening with the stars of winter and wrap up shortly before sunrise with a preview of what spring offers.

Every double in the tour is best seen between 50x and 150x, and lies within the reach of even the most modest of backyard telescopes. Each description includes how far apart they are from one another in arcseconds (") and a brief mention of their colors. Along with my impressions of the stars' colors, I've included those of the famous 19th-century double star observers Thomas Webb, William Henry Smyth, and William Herschel. With a little patience and practice, you too will see the hues that make observing colorful double stars so attractive.

I've also included some field drawings and a map that shows where in the sky each double is located. Use the coordinates under each drawing, along with a star atlas like *Sky Atlas 2000.0*, to find the star's precise location.

Let's begin our tour of colorful winter doubles by visiting Taurus the Bull, home to the very wide, colorful duo **Phi (ϕ) Tauri**. With a separation of 57", Phi's 5.0- and 8.4-magnitude component stars are a cinch for any small telescope. Its reddish-orange primary and blue companion, set against a sparse starfield, offer a captivating view. My 3- and 4-inch refractors, at 105x and 38x, respectively, reveal Phi's exquisite colors.

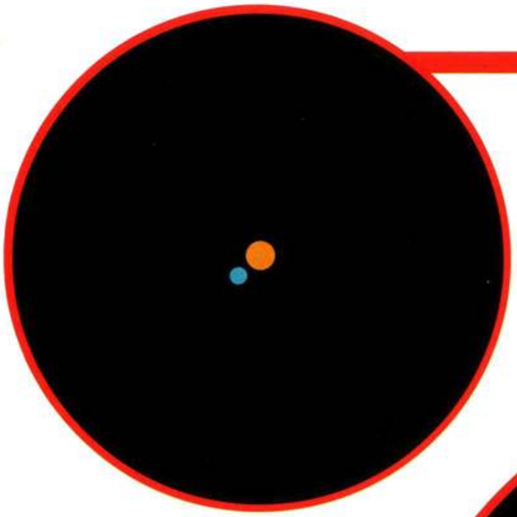
From Taurus we move immediately south to the Bull's next-door neighbor and mythological adversary, Orion the Hunter. Regarded as the harbinger of winter, Orion is home to some of the best double stars for 2- to 4-inch telescopes. Two of these pairs, **Delta (δ)** and **Rho (ρ) Orionis**, provide excellent contrasts in color and separation.

Delta Orionis, whose 2.2-magnitude primary and 6.3-magnitude companion are separated by 53", is best viewed at low power. Webb described the component stars' colors as whitish-yellow and pale lilac. Using a 3-inch f/11 refractor at 105x, and a 90 mm f/11 Maksutov-Cassegrain at 67x, I see a white primary and a purplish companion.

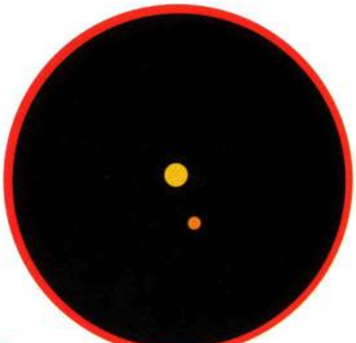
Rho Orionis, on the other hand, is composed of a 4.5-magnitude primary and 8.3-magnitude companion, separated by 7.0". Unlike Delta, Rho is best resolved, and its yellow-orange and blue contrast seen, with at least 50x. Using my 3- and 4-inch refractors at 105x and 67x, respectively, I cleanly split Rho's component stars and observe a yellow-orange primary and blue companion.

Moving westward beyond Rigel we find the next double star on our list, **Struve (Σ) 649**, in the constellation Eridanus. S649 is an unequal-magnitude system, with its 5.8- and 9.8-magnitude component stars separated by 22". It is best viewed using low magnification. William Herschel described S649 as white and very ruddy. My 4-inch f/9.8 refractor using 38x shows a whitish primary and purplish companion, nicely set against a sparse starfield.

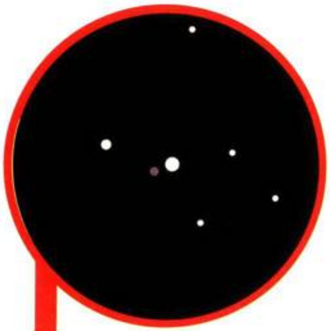
From Eridanus we now head south of Orion, into the domain of Lepus the Hare. Here we find the



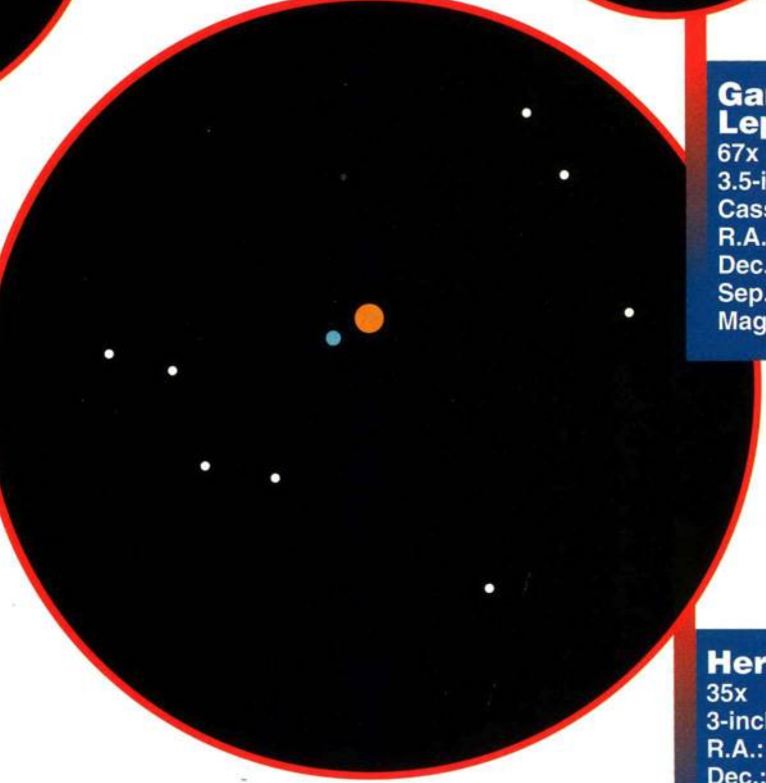
Rho (ρ) Orionis
105x
3-inch f/11 refractor
R.A.: 5h13.3m
Dec.: 2°52'
Sep.: 7.0"
Mags.: 4.5, 8.5



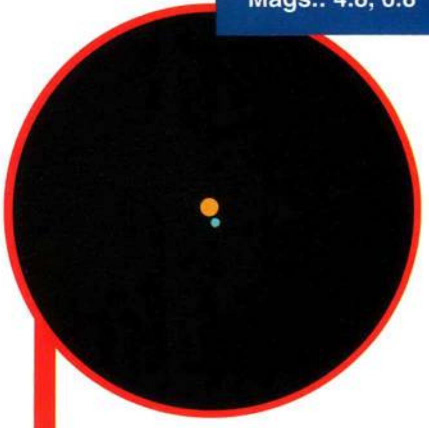
Gamma (γ) Leporis
67x
3.5-inch f/11 Maksutov-Cassegrain
R.A.: 5h44.5m
Dec.: –22°27'
Sep.: 96.3"
Mags.: 3.7, 6.3



Struve (Σ) 649
67x
4-inch f/9.8 refractor
R.A.: 5h08.3m
Dec.: –8°40'
Sep.: 21.6"
Mags.: 5.8, 9.8



Herschel (h) 3945
35x
3-inch f/11 refractor
R.A.: 7h16.6m
Dec.: –23°19'
Sep.: 27.2"
Mags.: 4.8, 6.8



Mu (μ) Canis Majoris
182x
3-inch f/11 refractor
R.A.: 6h56.1m
Dec.: –14°03'
Sep.: 3.0"
Mags.: 5.3, 8.6

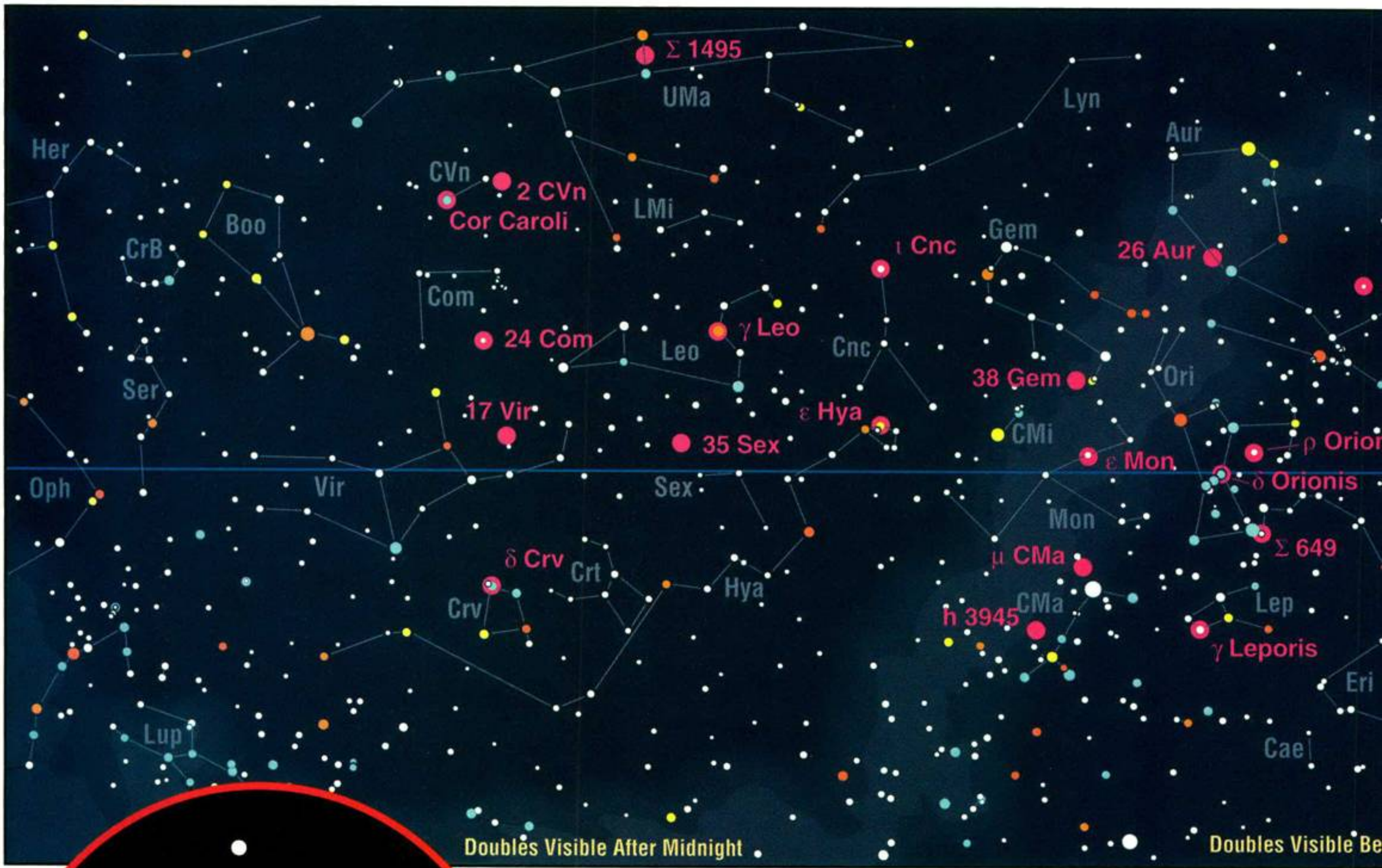
beautiful wide double **Gamma (γ) Leporis**. Gamma's 3.7-magnitude primary and 6.3-magnitude companion are easy at low power even with the smallest scope.

Their eye-catching colors have been described as yellow and pale green (Smyth) and yellow and garnet (Webb). With my 3-inch f/11 refractor at 105x, and my 90mm f/11 Maksutov-Cassegrain at 67x, I see Gamma's primary as yellow and the companion as orange-red, closely matching Webb's description. Focus your small telescope on Gamma Leporis and judge for yourself its color contrast.

Just east of Lepus is the constellation Canis Major the Great Dog, prominently marked by its beacon star, Sirius. The Milky Way runs down the back of Canis Major, and it is in these dense starfields that we find two highly colorful double stars, **Herschel (h) 3945** and **Mu (μ) Canis Majoris**.

Herschel 3945 is a wide double of 4.8- and 6.8-magnitude components best observed at low magnification. The color contrast of h 3945's primary and companion was described by Herschel as "high yellow and contrasted blue," and by Webb as "orange and blue." With my 3-inch f/11 refractor at 35x, I find a magnificent orange and blue contrast, one that matches Webb's description and resembles the color contrasts of Albireo in Cygnus and Andromeda's Almach.

On the other hand, Mu Canis Majoris is a much tougher duo for small scopes to deal with. Its 5.3- and 8.6-magnitude component stars, separated by only 3", may be difficult for a 2-inch scope, but it's definitely within reach of 3- and 4-inch scopes. You'll need at least 150x to split Mu's primary and companion and see their lovely


Σ 1495
UMa
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Com
γ Leo
Cnc
24 Com
Leo
Ser
38 Gem
Ori
17 Vir
ε Hya
CMi
35 Sex
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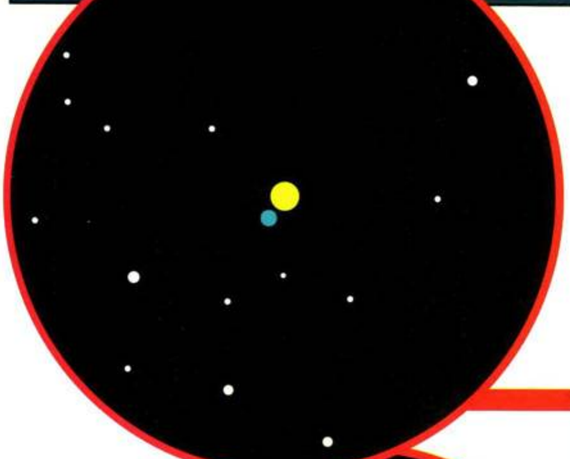
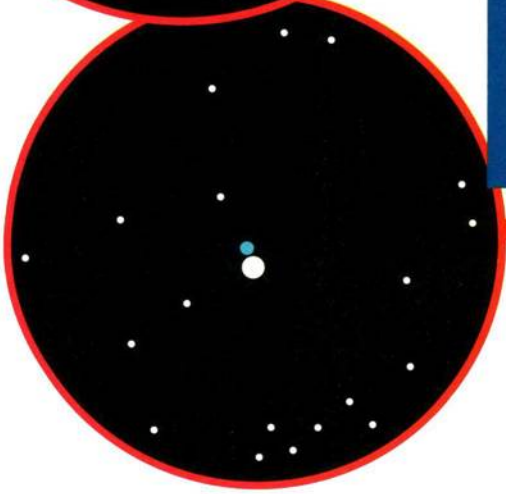


Iota (ι) Cancri
35x
3-inch f/11 refractor
R.A.: 8h46.7m
Dec.: 28°46'
Sep.: 30.5"
Mags.: 4.2, 6.6



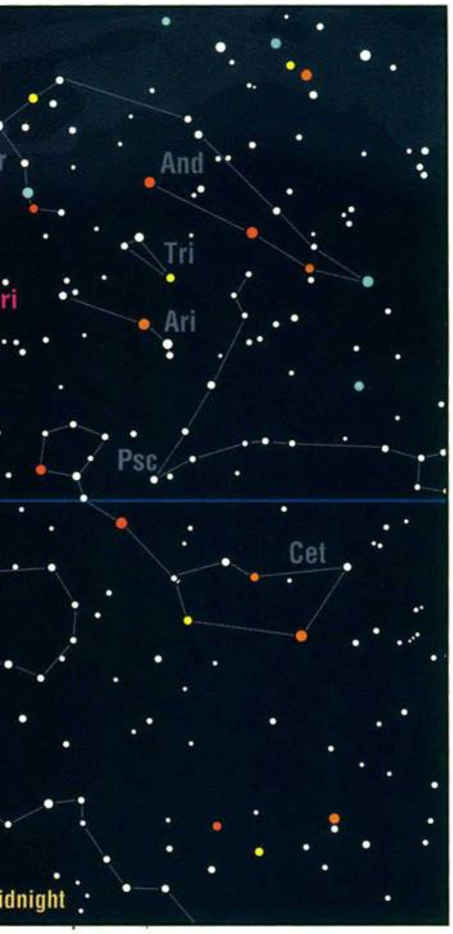
26 Aurigae
38x
4-inch f/9.8 refractor
R.A.: 5h38.6m
Dec.: 30°30'
Sep.: 12.4"
Mags.: 6.0, 8.0

yellow-orange and blue colors. My 3-inch f/11 refractor working at 182x reveals a bright orange primary and a deep blue companion for Mu. I concur with Herschel that Mu Canis Majoris' color contrast is indeed "most beautiful."

To the north of Canis Major lies the realm of Monoceros the Unicorn, and its fine resident duo, **Epsilon (ε) Monocerotis**. Situated about 2° due west of the Rosette Nebula, NGC 2244, Epsilon is a 4.5-magnitude primary and 6.5-magnitude companion separated by 13". Small telescopes using at least 35x will split Epsilon's component stars and view the nice yellowish and bluish color contrast. My 3- and 4-inch refractors, at 105x and 38x, respectively, yield a view of a light yellow primary and pale blue companion.

A short hop to the north is Gemini the Twins and its beautiful binary system **38 Geminorum**. With an orbital period of nearly 3,200 years, 38 Geminorum's 4.7-magnitude primary and 7.7-magnitude companion will reach a separation of 7.1" in 2000. Magnifications in the 50-100x range are recommended for small scopes to split the double and observe its fine colors, described by Webb as "yellowish and bluish." Through my 4-inch f/9.8 refractor at 38x and 67x, I see a whitish primary and a definitely blue companion.

As winter's stars slowly slip to the west, let's shift slightly west for a look at **26 Aurigae**, located approximately 4° northeast of



Beta (β) Tauri. Its 6.0- and 8.0-magnitude component stars, separated by 12", are easily observed with 2- to 4-inch scopes using 35x. The colors of the primary and its companion were reported by Webb as yellow and bluish. My 3- and 4-inch refractors, operating at 105x and 38x, respectively, show 26 Aurigae's color contrast as bright yellow and deep blue.

After midnight, winter's grip on the night sky yields to the promise of spring. Though the springtime stars may be fainter than their wintry cousins, they offer many a delectable target for the double star hunter.

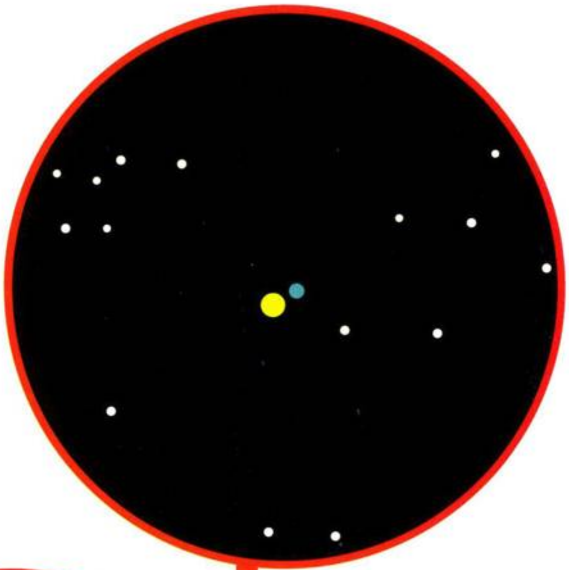
One of the most colorful pairs in the heavens, **Iota (ι) Cancri**, resides in Cancer the Crab. With its 4.2- and 6.6-magnitude component stars separated by 31", Iota requires only low power for you to see its striking golden yellow and blue color contrast. Iota's hues resemble those of Albireo in Cygnus the Swan. In fact, Iota is considered by some to be Albireo's springtime rival.

Using a 3-inch f/11 refractor at 35x and 105x, I see a jewel-like yellow-orange and blue color contrast produced by Iota's type G8 primary and type A3 companion. Aim your small reflector or refractor at Iota Cancri, and see if you agree that Iota is indeed a "springtime Albireo."

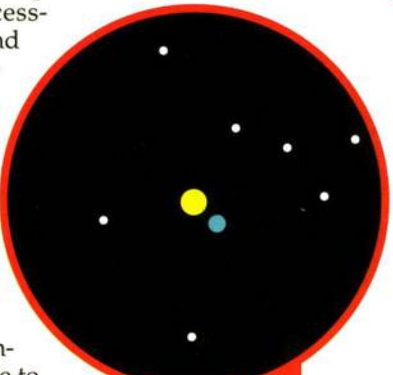
From Cancer it's eastward to the constellation Leo the Lion, where we find the beautiful binary system, **Gamma (γ) Leonis**, also known as Algebia from the Arabic "al Jabbah", the "Lion's Mane." Located in the region of Leo known as the "Sickle," Gamma's 2.2-and 3.5-magnitude stars are separated by 4.4". Two- to four-inch telescopes will require at least 100x to successfully split Gamma and reveal its components' warm, golden hues. With my 3-inch f/11 refractor at 105x, I see Gamma Leonis as a regal pair of close, golden, miniature Suns.

Directly south of Leo is the lengthy constellation Hydra, home to the beautiful and challenging binary star, **Epsilon (ε) Hydrae**. The northernmost star in the circlet of stars marking Hydra's head, Epsilon's primary and companion, of magnitudes 3.8 and 6.8 respectively, are separated by 2.7". You'll need at least 150x to successfully resolve this challenging pair into a lovely color contrast described by Webb as "yellow and blue." My 4-inch f/9.8 refractor required 200x to split the duo. I observe a yellow and pale blue-green, not too far off from Webb's description. Try to split Epsilon Hydrae with your small scope. What color contrast do you observe for this difficult double?

Nestled between Hydra and Leo is the small constellation of Sextans the Sextant and the colorful pair **35 Sextantis**. A 6.3-magnitude primary and 7.4-magnitude companion are separated by 6.8". This combination of a small magnitude difference and fairly close separation makes 35 Sextantis easy to split using 40x. However, the best resolution of 35 Sextantis' component stars, and the best view of their superb yellow and blue color contrast, is obtained by using 60x-100x.



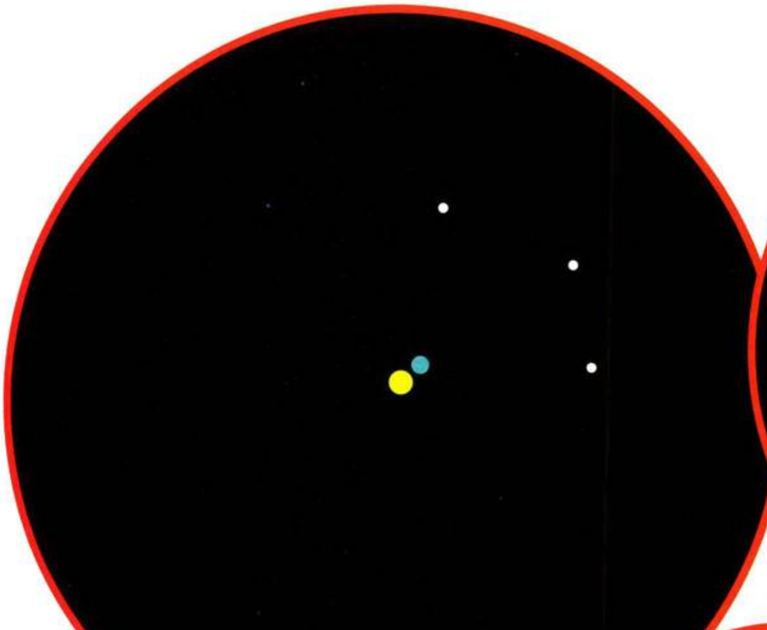
Epsilon (ε) Monocerotis
38x
4-inch f/9,8 refractor
R.A.: 6h23.8m
Dec.: 4°36'
Sep.: 13.4"
Mags.: 4.5, 6.5



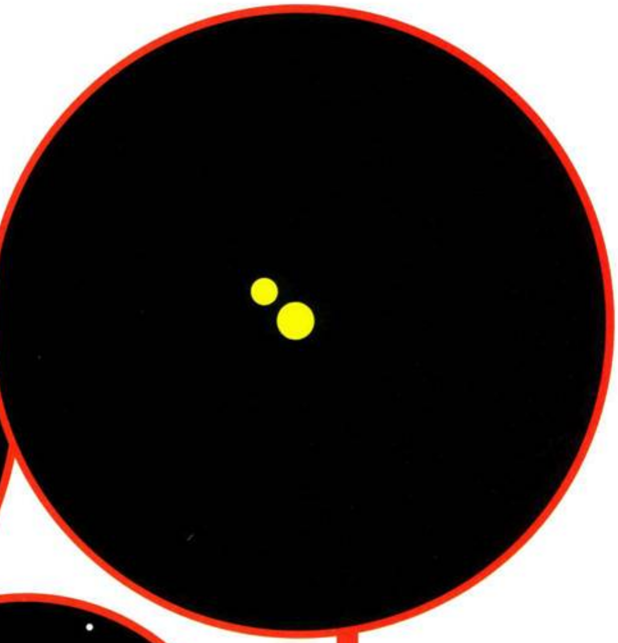
38 Geminorum
67x
4-inch f/9.8 refractor
R.A.: 6h54.6m
Dec.: 13°11'
Sep.: 7.1"
Mags.: 4.7, 7.7

My 4-inch f/9.8 refractor at 38x successfully split 35 Sextantis and shows a yellow-orange primary and blue companion. At 67x the colors of the component stars become more pronounced. Try viewing 35 Sextantis at both low and high magnifications, and judge for yourself which view is better.

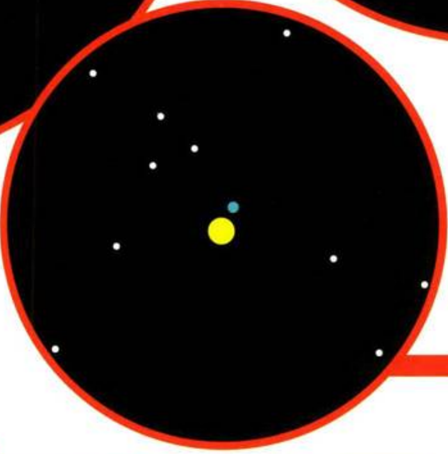
South and east of Sextans is the small, sparsely populated constellation of Corvus the Crow. Corvus is home to the wide double star **Delta (δ) Corvi**, also known as Algorab. Delta's 3.0- and 9.2-magnitude component stars are separated by 24", making this duo a perfect double for low-power observing in 2- to 4-inch scopes. The primary and companion stars share a common proper motion of 0.26" per year, indicat-



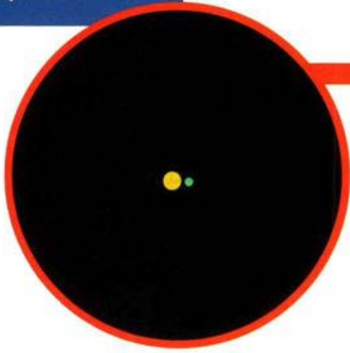
35 Sextantis
67x
4-inch f/9.8 refractor
R.A.: 10h43.3m
Dec.: 4°45'
Sep.: 6.8"
Mags.: 6.3, 7.4



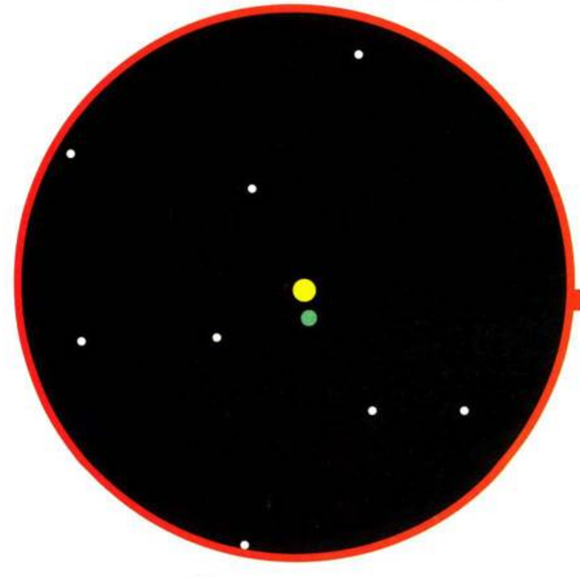
Gamma (γ) Leonis
105x
3-inch f/11 refractor
R.A.: 10h20.0m
Dec.: 19°51'
Sep.: 4.4"
Mags.: 2.2, 3.5



Delta (δ) Corvi
38x
4-inch f/9.8 refractor
R.A.: 12h29.9m
Dec.: –16°31'
Sep.: 24.2"
Mags.: 3.0, 9.2



Epsilon (ε) Hydrae
200x
4-inch f/9.8 refractor
R.A.: 8h46.8m
Dec.: 6°25'
Sep.: 2.7"
Mags.: 3.8, 6.8

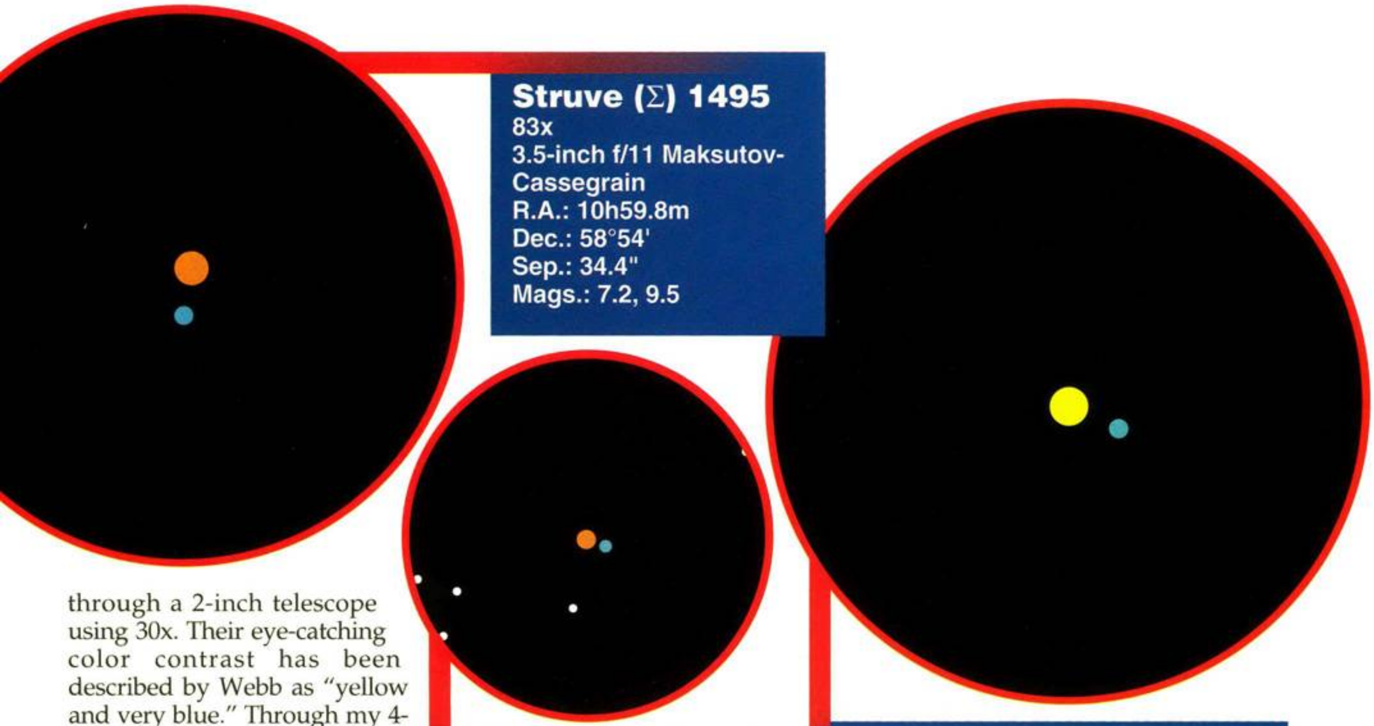


17 Virginis
38x
4-inch f/9.8 refractor
R.A.: 12h22.5m
Dec.: 5°18'
Sep.: 20.0"
Mags.: 6.6, 9.4

ing that they are orbiting one another. They display a color contrast commonly described as yellowish and pale lilac. Using my 4-inch f/9.8 refractor at 38x, I observe a whitish primary, with a hint of yellow, and a bluish-purple companion.

Above Corvus is the faint but well known constellation of Virgo the Maiden, popular with deep-sky observers for its Virgo Cluster of Galaxies. Hidden away in a sea of background galaxies is the colorful double star **17 Virginis**, composed of a 6.6-magnitude primary and a 9.4-magnitude companion separated by 20". Low magnification will do the trick when observing its lovely, but much debated, color contrast. Some observers report colors of rose and blue, white and blue, yellow and purple, or yellow-white and blue. Through my 4-inch f/9.8 refractor at 38x, I see them as light yellow and green.

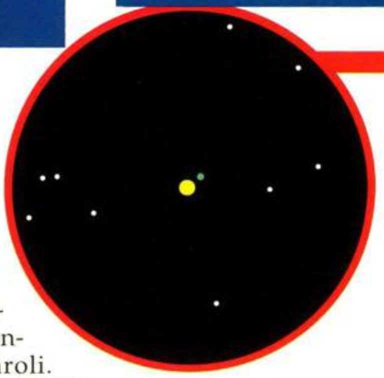
North of Virgo lies the constellation Coma Berenices and ***24 Comae Berenices***. Its 5.2- and 6.7-magnitude component stars, separated by 20", are wide enough to be viewed



Struve (Σ) 1495
83x
3.5-inch f/11 Maksutov-Cassegrain
R.A.: 10h59.8m
Dec.: 58°54'
Sep.: 34.4"
Mags.: 7.2, 9.5

24 Comae Berenices
38x
4-inch f/9.8 refractor
R.A.: 12h35.1m
Dec.: 18°23'
Sep.: 20.3"
Mags.: 5.2, 6.7

2 Canum Venaticorum
83x
3.5-inch f/11 Maksutov-Cassegrain
R.A.: 12h16.1m
Dec.: 40°40'
Sep.: 11.4"
Mags.: 5.9, 7.4



Cor Caroli
38x
4-inch f/9.8 refractor
R.A.: 12h56.0m
Dec.: 38°19'
Sep.: 19.4"
Mags.: 2.9, 5.5

through a 2-inch telescope using 30x. Their eye-catching color contrast has been described by Webb as "yellow and very blue." Through my 4-inch f/9.8 refractor at 38x, I glimpse a vivid orange and blue color contrast.

Due north of Coma Berenices is the equally sparse constellation of Canes Venatici the Hunting Dogs, and two lovely color-contrasted pairs for spring — **2 Canum Venaticorum** and **Cor Caroli**, also known as Alpha (α) Canum Venaticorum. 2 CVn's 5.9- and 7.4-magnitude component stars are separated by 11" and display a highly noticeable color contrast of gold and blue. For small telescopes using at least 40x, the star is truly a grand object. Using a 90-mm f/11 Maksutov-Cassegrain at 38x, I see a yellow primary and distinct blue companion. My 4-inch f/9.8 refractor, also at 38x, shows an orange primary and blue companion for this pair. The contrast is eye-catching.

Cor Caroli, the "Heart of Charles," named in honor of King Charles I of England, is also a very attractive double star. Its 2.9-magnitude primary and 5.5-magnitude companion, separated by 19", are an easy target for small apertures using at least 30x. Unlike 2 CVn, Cor Caroli's component stars display a subtle color contrast. Their contrast has been described by various observers as flushed white and pale lilac; Herschel recorded the pair as having "no contrast."

Reports of the companion's color have been discordant: pale olive, blue, pale copper (Webb), fine blue, and pale lilac. With my 90 mm f/11 Maksutov-Cassegrain at 38x, I see a white and greenish-blue color contrast for Cor Caroli. Through my 4-inch f/9.8 refractor, also using 38x, I observe a yellow-white and blue-green contrast. In both cases, the contrast was weak, but apparent.

No survey of colorful spring double stars would be complete without mention of **Struve (Σ) 1495**, located midway between the Big Dipper's pointer stars, Dubhe and Merak. Struve 1495 is easily observed with 2- to 4-inch scopes using 30x, as its 7.2-magnitude primary and 9.5-magnitude companion are separated by 34". The double's orange and blue color contrast is readily noticed against the sparsely populated starfield in which it lies. Using 38x with a 90 mm f/11 Maksutov-Cassegrain and a 4-inch f/9.8 refractor, I see a distinct orange and blue color contrast for Σ1495 through both scopes.

By the time this last harbinger of spring is well placed, you might notice a trace of dawn's early light lining the eastern horizon. Now that you've discovered these doubles of winter, try revisiting them with different telescopes. Invite some friends along to get a different set of impressions. Perhaps, along with you, they too will get hooked on the doubles of winter. ☐

Mark T. Stauffer uses a variety of telescopes to eye his favorite double stars from Pittsburgh.

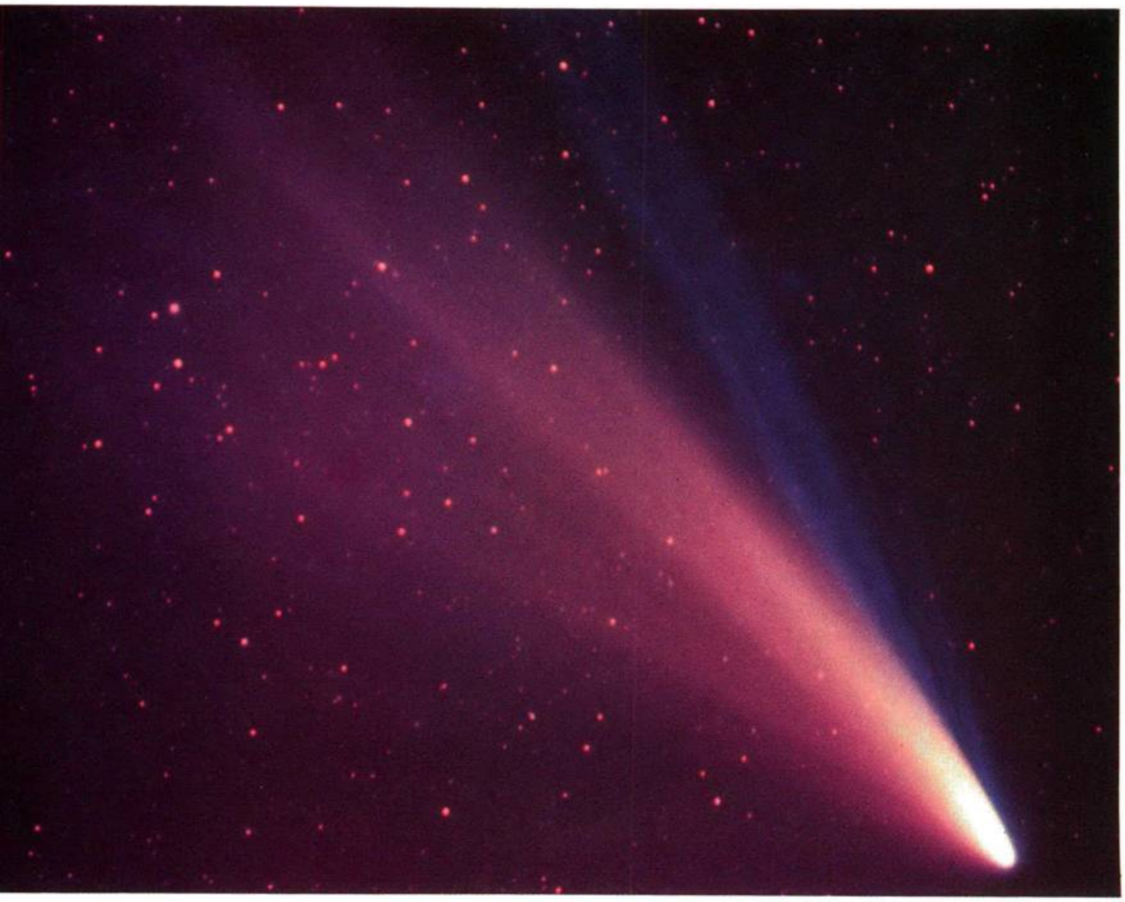
CATCH A COMET ON

When Hale-Bopp arrives, everyone will want to be a comet photographer. Here's how to become an expert.

by Rick Dilsizian

Who can forget their first view of a bright comet? For many of us it was Comet West, a shimmering spectacle of the morning sky in early spring 1976. Now a new comet, Hale-Bopp, promises to become the best in years, if not since West. This summer Hale-Bopp will reach naked-eye brightness. By spring 1997 it should blaze forth with enough light to impress even the most jaded neighbors.

To remember your Hale-Bopp experience, you'll probably want to record the comet in photographs. Three methods of increasing complexity allow you to do this in three ways. Mounting your camera on a tripod, loading it with fast film, and taking a short exposure with a wide-field lens captures bright comets as they loom over the horizon. Piggybacking your camera atop a telescope and guiding it as it tracks the stars permits a closer, longer exposure that shows more detail in the comet. Shooting through the telescope itself or employing a Schmidt camera, a specialized, wide-field camera made for astrophotography, records a sharp, closeup portrait of the comet. Before exploring the ins and outs of these techniques, however, let's step back and look at the nature of comets.



Comet West's Gas and Dust Tails
by James L. Matteson
(5½-inch f/1.65 Schmidt camera, Fuji F100 film, 2½-minute exposure taken in 1976)

Comets are small, solid bodies best described as dirty snowballs. The Oort cloud, located on the extreme outer edge of the solar system, is a vast reservoir of comets. Many of these comets spend their lives huddled in this cloud in the icy depths far beyond Neptune and Pluto. Others, however, *visit the inner solar system*, swinging by the Sun on elliptical, parabolic, or hyperbolic orbits.

FILM

When they roam inward the Sun gently heats their fluffy material, creating gas and dust tails that stream away from the Sun. This happens when frozen ices on the surface of a comet turn from a solid to a gas.

Choosing a Lens and a Film

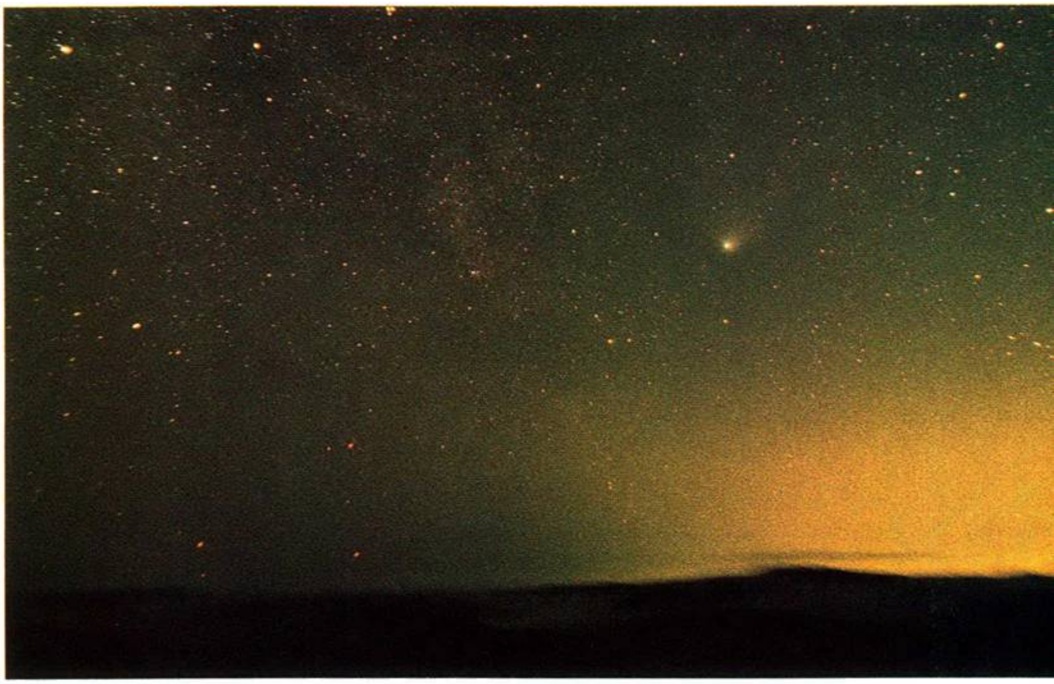
Contrary to popular belief, comets do not swoosh across the sky like giant meteors. They are pretty stationary each night, moving only slowly relative to the background stars. So you can photograph a comet with relatively simple equipment: a camera, a suitable lens, a tripod, and a roll of fast film.

The focal length of the lens to use depends on the comet's size. A long tail calls for a wider angle lens, such as a 24mm or 28mm focal length lens. A short tail calls out for a longer focal length lens such as a moderate telephoto with a 200mm to 300mm focal length. To choose a lens based on a specific comet size, see the table on page 81.

Imagine, for example, that you want to photograph Hale-Bopp's 10°-long tail. Either use a 200mm lens to capture the entire comet across a full frame of film, or employ a 135mm lens and the comet will cover half the film frame. Or photograph the comet with a 50mm lens and it will cover only 1/4 the length of the frame.

This is fine, but what if you don't know the comet's angular size? Gauge it by looking at the constellations to see where the comet starts and ends, then find those positions on a star chart and figure the angular distance from those points. Or, hold out your fist at arm's length. For most people, this is approximately 10 to 12° on the sky. By placing your fist at the coma and working back toward the end of the tail, the number of fists multiplied by 10 or 12 should approximate the comet's length in degrees.

Once you know about how the large comet is and what lens to use, it's time to consider film. The speed of the film to try depends largely on the type of technique you are going to use. For camera-and-tripod photography, use the fastest film



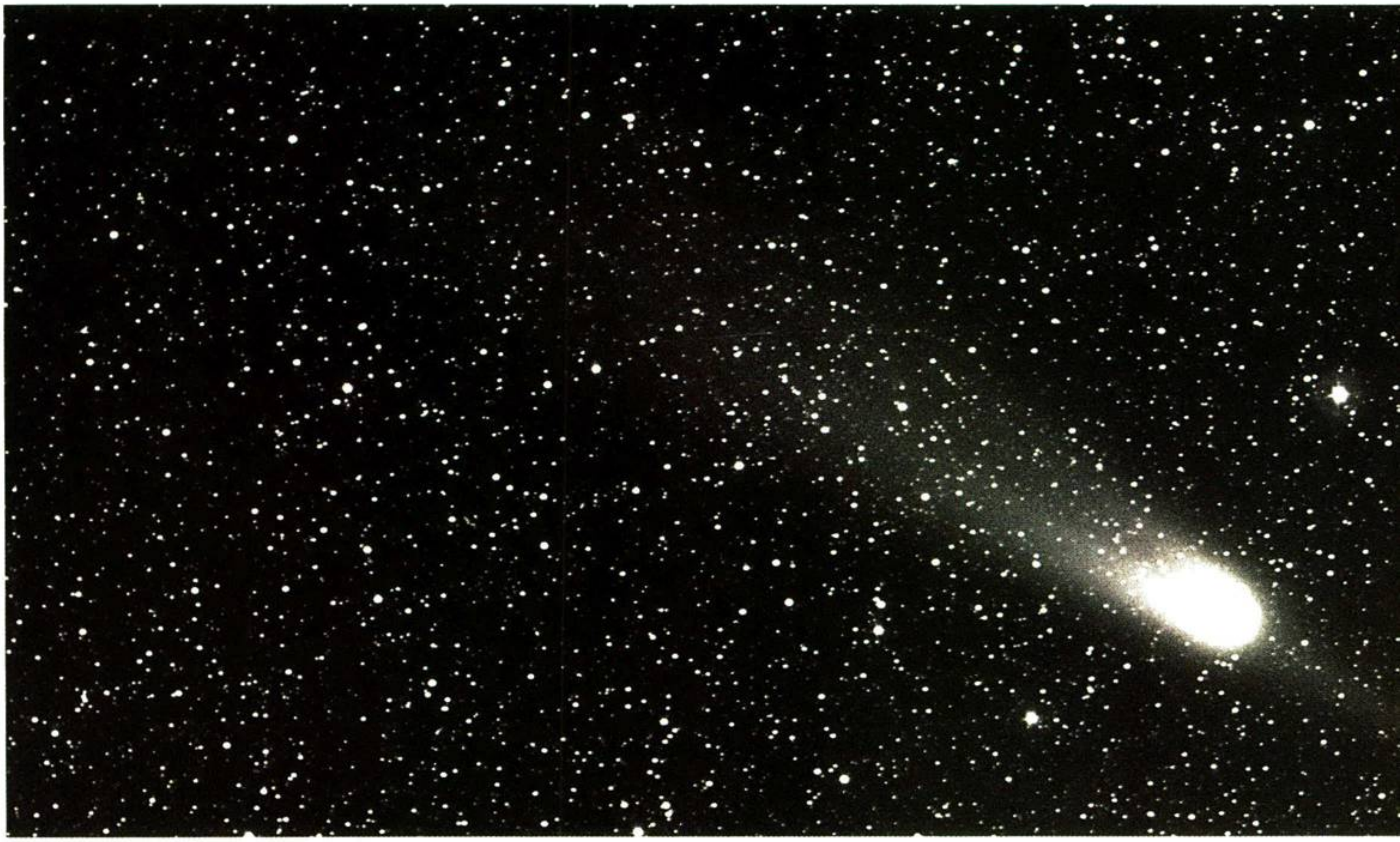
Halley Hangs Over the Southern Horizon

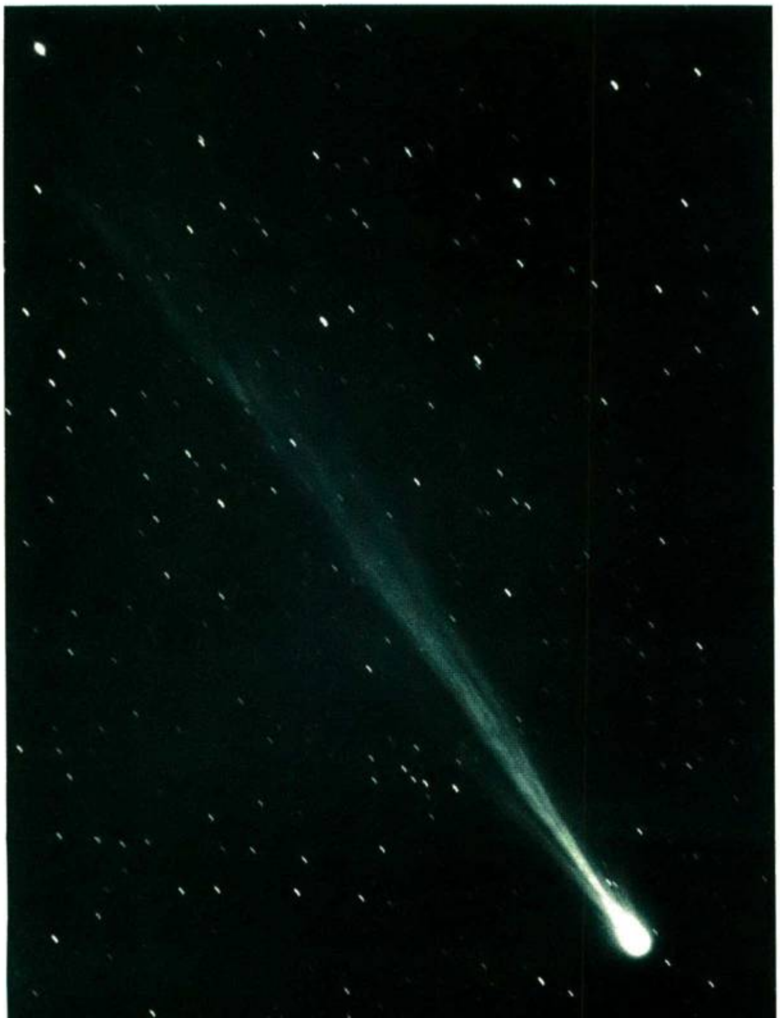
by Jeff Schroeder
(50mm lens at f/2.8, Ektachrome 400 film, 2-minute exposure taken April 8, 1986)

Exposure Times and Camera-and-Tripod Setups

If your lens focal length is . . .	Expose for . . .
24mm	40 to 60 seconds
50mm	15 to 25 seconds
135mm	5 to 10 seconds
200mm	2 to 5 seconds

Camera-on-Tripod. The simplest, limited to short exposures.





Comet Bradfield Sports an Antitail

by Chris Schur
(8-inch f/1.5 Schmidt camera, hypersensitized Tech Pan film, 10-minute exposure with a yellow filter, taken December 20, 1987)

What Makes a Comet?

Comets are small bodies in the solar system orbiting the Sun at generally very great distances. Occasionally, however, comets from the distant Oort cloud are carried in toward the Sun, where they pass close to it before heading back out. When this occurs, their dirty snowball composition warms and releases a tail of particles stretching as far as millions of miles across. The comet's nucleus — its icy mudball — a dense envelope of particles called a coma, and long dust and gas tails become visible in backyard telescopes, binoculars, or even to the naked eye.

Comet Ikeya-Seki's Twisting Tail

by James Cornell
(Smithsonian Astrophysical Observatory, taken in October 1965)

Comets on the Net

- Comet Places on Line. A directory of images, data, and links on the Net. http://fly.hiwaay.net/~cwbol/astron/comet.html
- Comets. The University of Arizona's comet roundup. http://seds.lpl.arizona.edu/billa/tnp/comets.html
- International Comet Quarterly. Information on the primary comet publication along with sample pages. http://cfa-www.harvard.edu/cfa/ps/icq.html
- JPL's Comet Hale-Bopp Home Page. Many images and the latest on this brightening comet. http://newproducts.jpl.nasa.gov/comet/
- Gary Kronk's Comet Page. Images, positions, and magnitudes. http://medicine.wustl.edu/~kronkg/
- NASA's Comet Observation Home Page. A smorgasboard of comet information and images. http://encke.jpl.nasa.gov/
- Tom Polakis' Comet Page. Quicktime and MPEG movies of the orbit of Comet Hale-Bopp. http://www.indirect.com/www/polakis/halebopp.html

available to capture as much as possible in a short exposure.

Because comets show both blue gas tails and yellow dust tails, choose daylight film. Good color films include Konica's SRV 1600 or 3200 for color negatives and Fujichrome's RSP (1600) for color slides. For black and white, consider Kodak's T-Max 400 or 3200.

Camera, Tripod, Comet, Sky

Camera-and-tripod photography is easy. Set up your tripod, load the camera with film, and attach a cable release. The cable allows you to open the shutter for a period longer than the very short exposure used with everyday pictures at the beach. Focus the camera lens to infinity and aim the camera so the comet and a field of stars appears in the viewfinder, or so you know the comet is in the field even if you can't see it in the finder. Set the aperture of the camera one or two stops slower than wide open.

Next, place an opaque piece of cardboard in front of the lens. Depress the cable release to open the shutter and wait several seconds before you remove the cardboard. This minimizes vibration that could ruin your negative or slide. Time the exposure with either a stopwatch or count out loud. To end the exposure, place the cardboard in front of the lens before releasing the cable button to close the shutter. That's all there is to it.

The exposure table (see p. 79) provides a good starting point for a camera-and-tripod setup. Don't be afraid

Lenses for Comet Photography

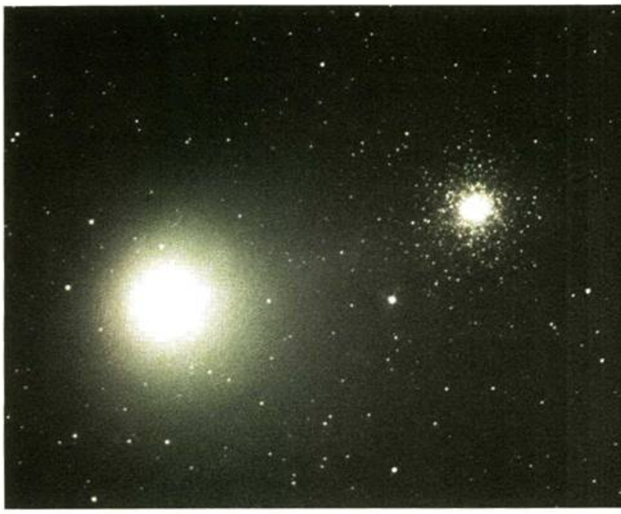
If a Comet is this long. . .	Use this lens. . .
100°	18mm
80°	24mm
60°	35mm
40°	50mm
20°	135mm
10°	200mm
5°	400mm

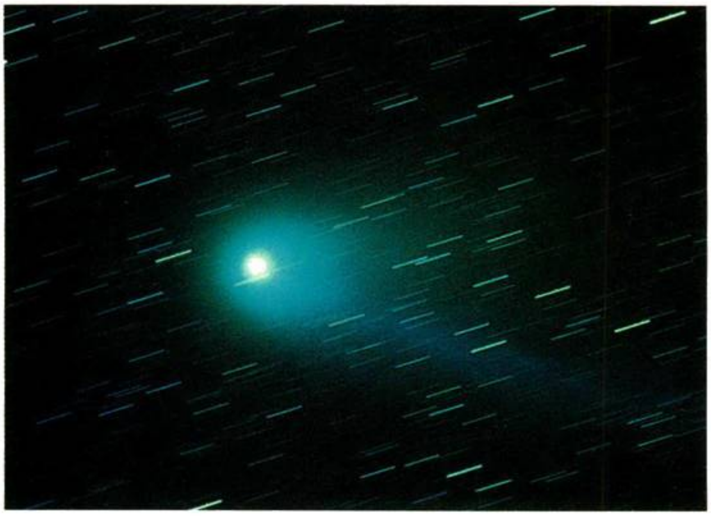
Piggyback. Requires a tracking telescope; creates stunning, wide-field images.

Comet Levy Passes Globular Cluster M15

by Dennis Sørenson

(10-inch f/6 reflector, T-Max 400 film, 10-minute exposure taken August 18, 1990)





Comet Levy's Fan-Shaped Coma

by Michael Stecker (8-inch f/4 reflector, hypersensitized Fujichrome 100, taken August 26, 1990)

to experiment with different exposures. In short exposures, stars will appear round. In long exposures, stars will appear as trails because they track across the film as Earth rotates. The comet may appear as a trailed smudge of light. For more on simple camera-and-tripod astrophotography, see "Nightscapes" by Robert Bunge, ASTRONOMY, June 1992.

Piggyback Astrophotography

Piggybacking means placing the camera atop a telescope and tracking the telescope's drive on the stars during the exposure. This allows longer exposures, minimizes star trailing, and makes the choice of films less critical. Finer grained, slower films with higher resolution work with piggyback method. Such color films include Konica's SRV 400 color negative film and Kodak's Ektachrome 200 and 400 and Fuji's Fujichrome 400 for slides.

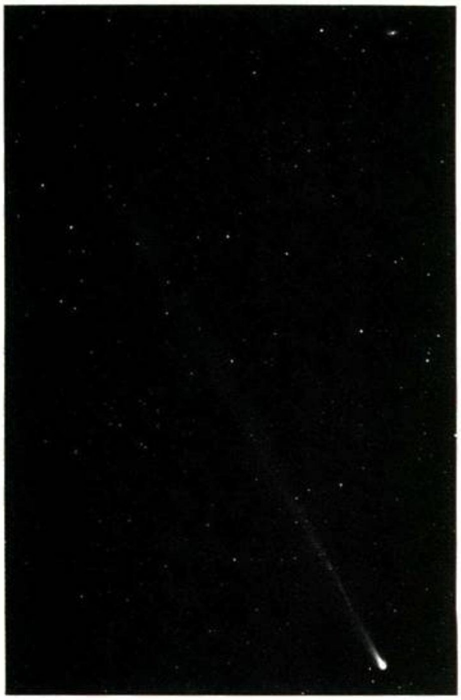
The best black and white film is Kodak's Technical Pan film, but it works best when hypersensitized, or chemically treated to maximize its speed. Hypered Tech Pan can be purchased from a number of advertisers in ASTRONOMY.

Attach the camera to the telescope with a piggyback mount. Hook up the cable release. Center the comet in the camera's viewfinder. Before taking an exposure, locate a guidestar near the comet to guide on during the exposure. Or you may wish to guide on the brightest part of the comet itself, the coma.

If the comet moves a substantial distance across the sky in one night, guide on the coma instead of a guide star. The comet will be changing position relative to the stars quickly enough that it may appear as a blur if you guide on a star.

How do you know how far across the sky a comet will move in an hour? The best way is to subscribe to a publication that provides positions for newly-discovered comets such as the *Comet Rapid Announcement Service* (P.O. Box 110282, Cleveland, OH 44111; e-mail 72527.364@CompuServe.com). This publication provides positions of newly found comets within days of their discovery, and includes magnitudes and other data where possible.

Piggyback astrophotography is a real art that must be practiced thoroughly for success. For a complete backgrounder on piggybacking, see "Give Your Camera a Piggyback Ride" by Rick Dilsizian, ASTRONOMY, April 1987.



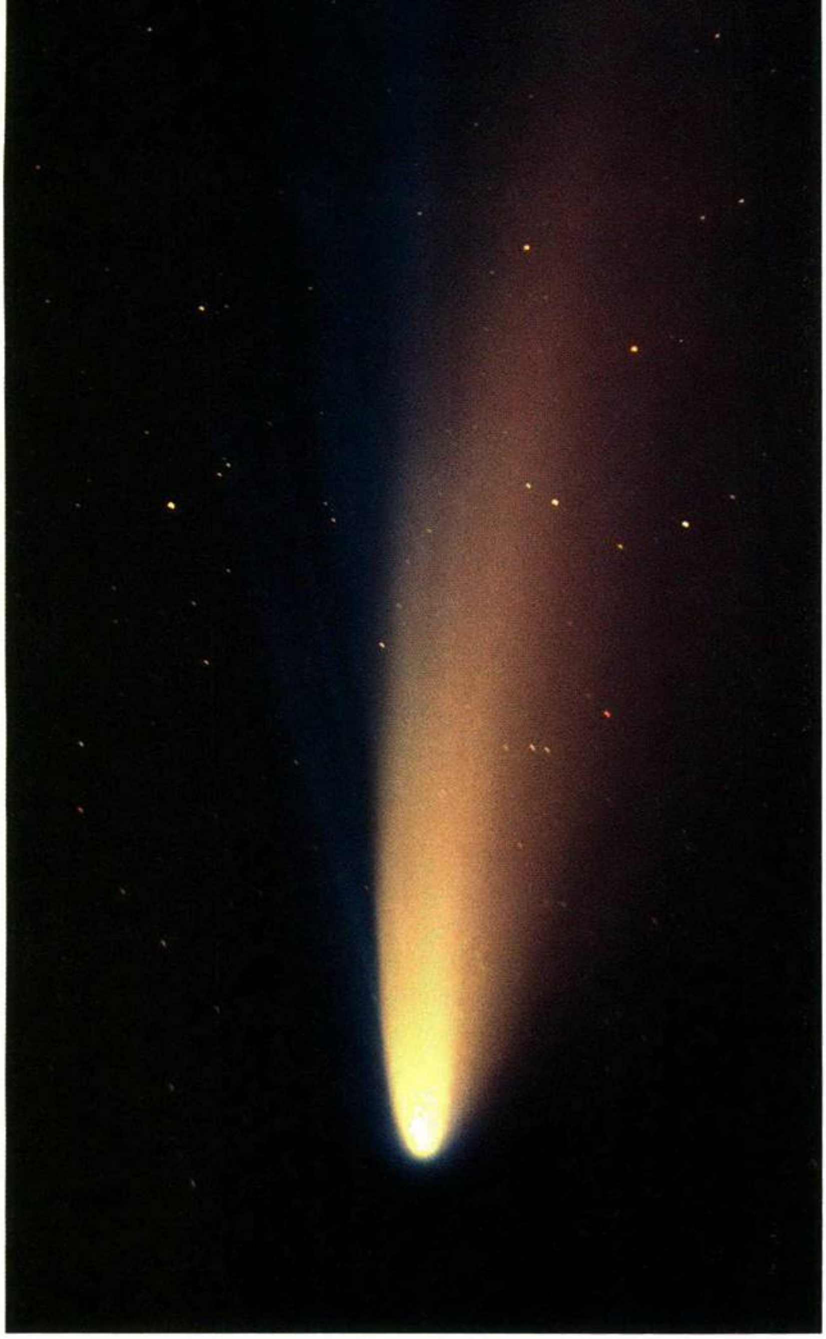
Brorsen-Metcalf's Long Tail

by Martin Hale (8-inch f/1.5 Schmidt camera, hypersensitized Tech Pan film, 3-minute exposure taken September 9, 1989)

Telescopes and Schmidt Cameras

The last type of comet astrophotography is the most complex. Shooting through the scope means using a separate guidescope or an off-axis guider to track on a star during the exposure. Using a Schmidt camera, on the other hand, allows you to guide using the main telescope. A Schmidt camera is a special astrophotographic camera de-

Telescope or Schmidt Camera. Tricky, complex logistics, but yields a high-resolution portrait of the comet's details.



Closeup on Comet West

by Robert Provin (taken in 1976)

signed for crisp, wide-field views of Milky Way, galaxies, and comets.

Either of these advanced techniques requires precise polar alignment, excellent guiding, and tricky film handling. With prime focus photography, long exposure times are needed because of the slow f/ratios of 5 to 10 involved. That means that fast, hypersensitized films should be used. For more details on these types of photography, see "Prime-Focus Astrophotography with Small Telescopes" by Andrew Packer, ASTRONOMY, April 1988; "Tools for Prime-Focus Astrophotography" by David J. Eicher, ASTRONOMY, April 1988, "Taming the Schmidt Camera" by Robert Reeves and Mace Hooley, ASTRONOMY, December 1987, and "Taking Pictures with Your Telescope" by Alan Dyer, ASTRONOMY, December 1992. Also, check out a couple of helpful books: *Astrophotography for the Amateur* by Michael Covington (Cambridge University Press, New York, 1991), and *Introduction to Observing and Photographing the Solar System* by Thomas A. Dobbins, Donald C. Parker, and Charles F. Capen (Willmann-Bell, Richmond, 1988).

Filters for Comet Photography

Filters help enhance images of comets on film. Comets often appear brightest when they're close to the Sun in the sky, Comet West being the most recent bright example of this. This means they're at their best in morning or evening twilight. However, scattered light from the Sun has the distinct characteristic of washing out cometary details because the sky background becomes bright.

To help reduce this effect, try a blue filter like a Wratten 47. The filter will transmit primarily the light of its own color. Filtering out red light from the sky will increase the contrast of your comet photos near dawn or dusk.

When a comet appears lost in the blue sky of morning as the Sun continues to rise or in the pre-evening daytime sky, try a yellow filter like a Wratten 6, 8 or 9.

Comets are those celestial hobos of space. They're dirty, dusty and icy. The next time you see one, photograph a comet and capture a lasting memory of this beauty. ☐

Rick Dilsizian is a professor of mathematics at Westchester Community College in New York. He has written frequently for ASTRONOMY.

A Bright Comet in Your Future

Comet Hale-Bopp, discovered by two amateur astronomers on July 22, will brighten to become the best comet in 20 years, according to the calculations of Brian G. Marsden of the International Astronomical Union. The comet's closest passage to Earth will occur on April 1, 1997, when the comet may shine as brightly as magnitude –2 and sport a tail between 10° and 20° long.

The comet will reach naked-eye brightness this summer.

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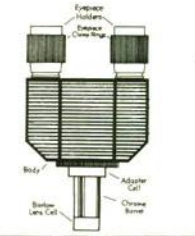

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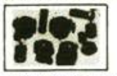

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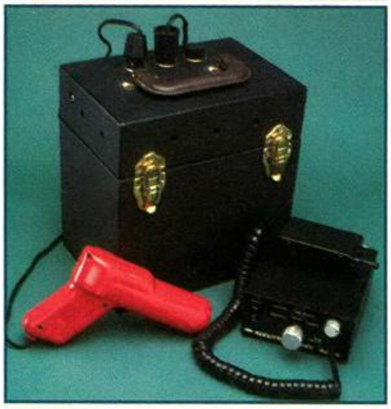


Dark skies seldom come with electrical outlets. Here's an easy weekend project that can power a telescope and two electrical accessories for hours.

By Joseph Kempter

Urban observers are like observational nomads. But getting away from the city lights of civilization also means being far removed from electricity. Like me, most nomads turn to their car for power, plugging into a cigarette light or clipping into a battery.

After years of coping with wire umbilicals and dead car batteries, I've finally streamlined my power needs into a simple wooden hinged box that houses a deep-cycle marine battery. It's easy to stow and carry and offers three fused, cigarette lighter power sockets. My "power box" weathers the power demands of an LX-200, a 1-amp dew heater, a map light, and repeated use of a 12-volt, 15-amp hair dryer for up to six hours. Best of all, when the battery is hooked up to a trickle-charger with a 6-amp charging rate, it recharges in two to three hours.

Getting Started

Make your battery box out of ½-inch birch plywood that's finished on one side; the unfinished side can face inward. After cutting pieces for the box and lid sections (see the diagram for dimensions), check that all sides fit. Set aside everything but the lid until later.

Drill and countersink three ⅞" holes into the lid's unfinished side for lighter sockets. The three cigarette-light socket holes must be to the rear side of the lid. Countersink with a 1⅛" flat spade, and then mark the countersunk face of the lid plate "bottom side."

Glue all the sides together using carpenter's glue (not white glue). Note that side pieces are glued against the lid and base plates' ends, not to the faces. Before the glue has set, drive in 1" brads. Set them about 1/16" below the surface and plug each set hole with plastic wood. Let everything dry thoroughly for 8 to 10 hours before starting the next step.

Now it's time to drill ventilation holes into the lid. Mark "front" and "rear" (edge closest to the socket holes) on the lid to avoid placing centers for nine holes in the wrong areas. Now drill three ¼" holes on each of the lids' sides, except the back. The holes farthest to the rear on the right and left sides are for terminal bolts used for wiring the battery circuit in a later step. The other seven holes are for ventilation.

Lid Meets Base

Trim the continuous hinge to a length of about 8" with a hacksaw. After cutting the hinge, mark screw hole positions, drill pilot holes, and then attach the hinge with screws.

Mount the box's two draw catches and handle by drilling pilot holes and installing them with screws. To keep the lid from opening too far, cut a 7½" length of ⅛" nylon cord and seal both ends with a lit match. Remove the plastic sleeves from two 12-gauge ring connectors. Crimp one connector to each end of the cord. Use a short pan head screw to install one end of the cord on the inside edge of the cover, 2½" from the front. With the cover open a bit past 90 degrees, mark the cord's other end on the inside wall of the box and secure with a screw.

Finally, remove all attachments and apply several coats of flat black paint; you may wish to coat the box's exterior with several coats of polyurethane.

Go Electric

The next step is to install cigarette lighter sockets and wire the circuits. Strip insulation 5/16" from the ends of all the wires. Use pliers and a twisting motion to remove the plastic sleeves from all ring connectors.

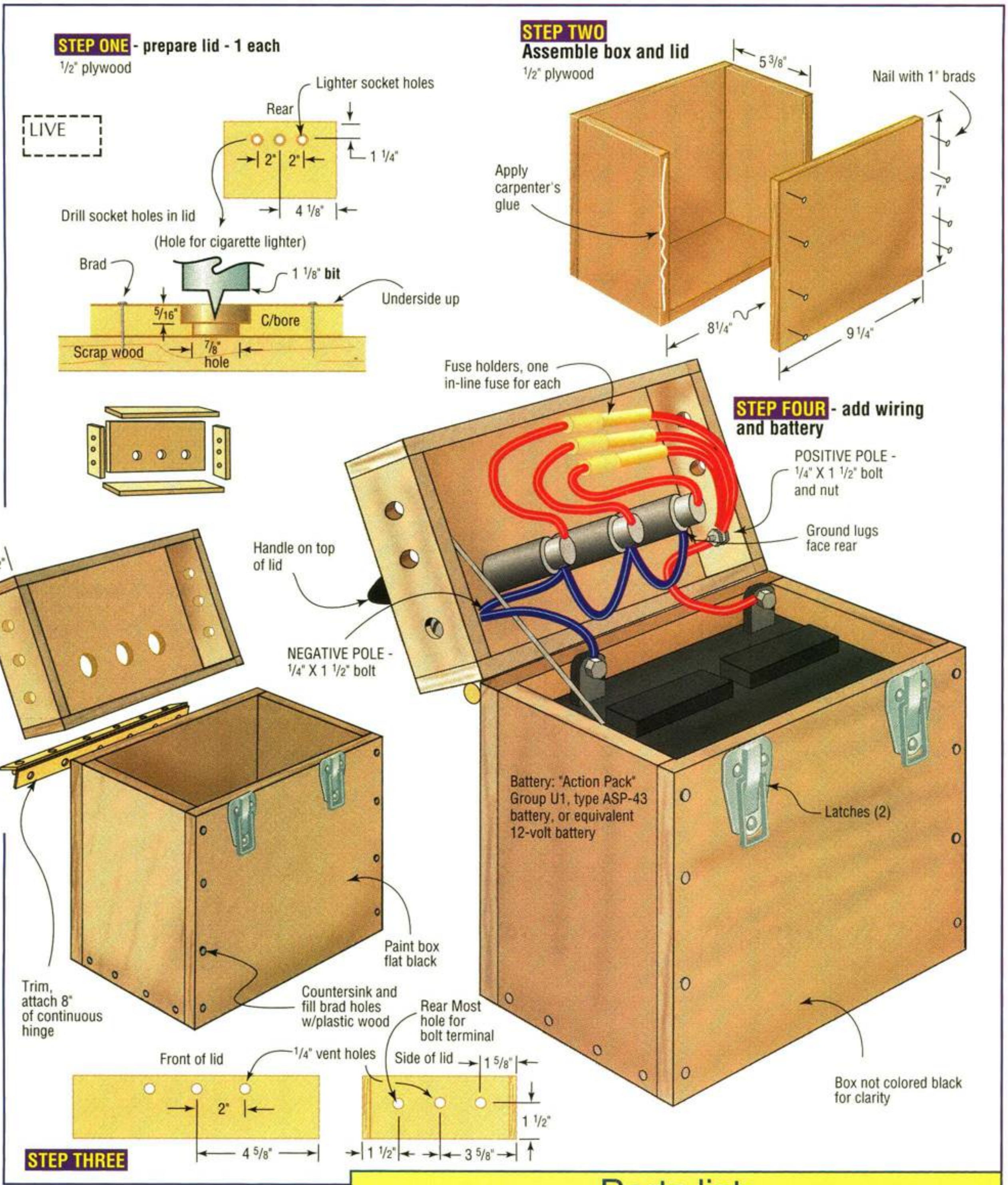
Install the lighter sockets by unscrewing the outer retainer shells from three lighter sockets and inserting the sockets into the holes in the lid. Reinstall the retainer shells and rotate each socket in its mounting hole so ground lugs face the rear side of the cover. Solder 14-gauge wire to each socket's ground lug. Use a ring connector to attach the end of each of these three wires to a ¼" 1½"-long round-head bolt, flat washer, and a nut you've installed on the left side of the lid.

There is one additional wire on this bolt, seven inches long with a ring connector soldered on each end. Secure one end, along with the other three connectors running from the cigarette-lighter sockets, to the bolt with a nut and lockwasher. The wire's other end eventually connects to the battery's negative post.

Now wire the positive side of the circuit. Solder the wire from each fuse holder to the central terminal lug of a cigarette-lighter socket. Run the wire that protrudes from the other end of each fuse holder to the lid's right bolt. Crimp a ring connector to the end of the wire so it will slide onto the bolt. Install one additional wire on this bolt that is seven inches long and has a ring connectors attached to each end. Secure one end of this wire, along with the three other feeds from the fuse assemblies, to the bolt with a nut and lockwasher. The other end of the wire connects to the battery's positive post.

Finally, use two ¼" Std. ¾" length bolts, lockwashers and nuts to connect the wire from the lid's right side to the negative post of the battery and the wire from the lid's left side to the positive post of the battery. If you own a circuit-tester, check each socket for current.

Congratulations on completing your three-outlet battery box.


STEP ONE - prepare lid - 1 each
1/2" plywood
LIVE
Lighter socket holes
Rear
2"
2"
1 1/4"
4 1/8"
Drill socket holes in lid
(Hole for cigarette lighter)
Brad
1 1/8" bit
Underside up
5/16"
C/bore
Scrap wood
7/8" hole
STEP TWO
Assemble box and lid
1/2" plywood
5 3/8"
Nail with 1" brads
Apply carpenter's glue
7"
8 1/4"
9 1/4"
Fuse holders, one in-line fuse for each
STEP FOUR - add wiring and battery
POSITIVE POLE - 1/4" X 1 1/2" bolt and nut
Ground lugs face rear
Handle on top of lid
NEGATIVE POLE - 1/4" X 1 1/2" bolt
2 1/2"
Battery: "Action Pack" Group U1, type ASP-43 battery, or equivalent 12-volt battery
Latches (2)
Paint box flat black
Trim, attach 8" of continuous hinge
Countersink and fill brad holes w/plastic wood
Rear Most hole for bolt terminal
Box not colored black for clarity
Front of lid
1/4" vent holes
Side of lid
1 5/8"
2"
1 1/2"
4 5/8"
1 1/2"
3 5/8"
STEP THREE

Show it off to your friends with the confidence that you'll never get caught short of power out under rural skies. After a few observing sessions under dark skies, you'll agree that boxed power is an astronomical nomad's dream come true. ☐

Joseph Kempter is a retired automotive mechanic who drives 30 miles to escape the lights of metro-Milwaukee.

Parts list:

"Action Pack" Group U1, Type AP-34 battery (Mfg. by GNB, Inc. of St. Paul, MN; call (800) 289-4627 for the nearest dealer)

½" birch plywood, finished on one side

Carpenter's glue

1" brads (or finishing nails)

Continuous hinge at least 11" long

(4) 8-32 by ¾" screws, nuts, and flatwashers

20" of ⅛" nylon cord

Handle (Brainherd part #1281-xc)

(2) draw-catches (Brainherd part #0864-xc)

(3) cigarette lighter sockets (Casco 212111universal or Victor-v5410)

(3) inline fuse holders

2 feet of 14 gauge wire

(2) 12 gauge ring connectors

(10) 12 gauge ring connectors (stud size ¼")

(2) short pan head screws

(2) ¼" Std. 1½" long round head bolts, lock washers, flat washers and nuts

(2) ¼" Std. ¾" length bolts, lockwashers and nuts

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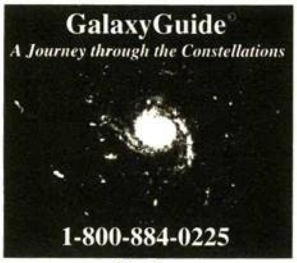

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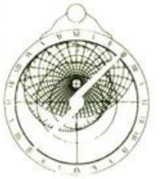

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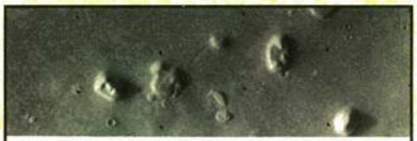

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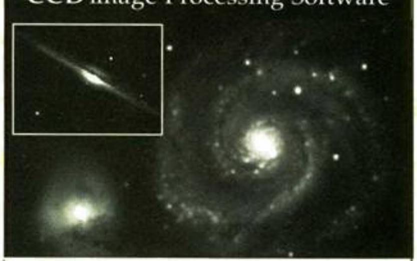

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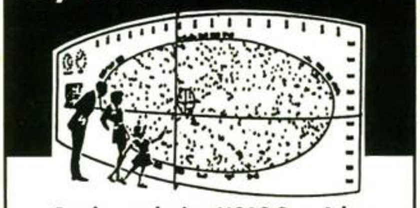

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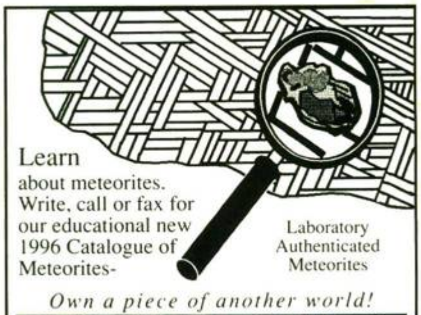

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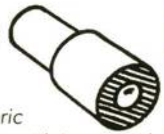

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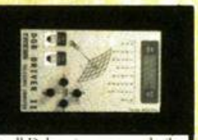

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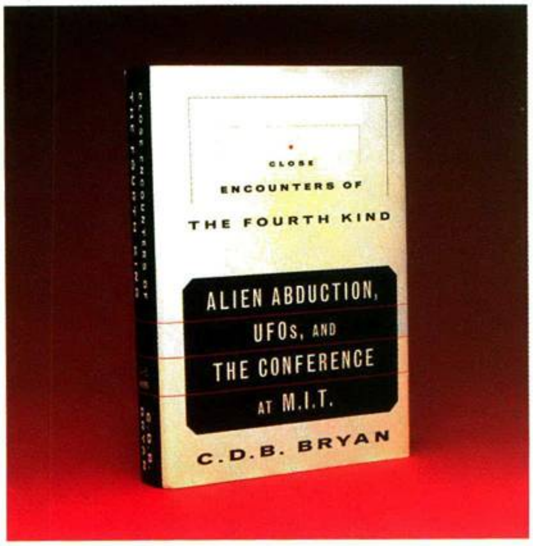
What I Did On My Alien Abduction

Close Encounters of the Fourth Kind: Alien Abduction, UFOs, and the Conference at M.I.T.
C. D. B. Bryan, (Alfred A. Knopf, 1995), ISBN 0-679-429753, 465 pages, hardcover, $25.


CLOSE ENCOUNTERS OF THE FOURTH KIND
ALIEN ABDUCTION, UFOs, AND THE CONFERENCE AT M.I.T.
C.D.B. BRYAN

Let's face it, most astronomers lump topics like UFOs and alien abductions under the same category with spontaneous human combustion and astral traveling. I can attest to this because, during my tenure as a public information officer at the University of Texas McDonald Observatory, I was usually the one thrust before TV cameras and reporters when answering inane questions about UFOs and other unexplained phenomena. Astronomers wanted no part of the supernatural.

And who can blame them? Since pilot Kenneth Arnold first saw a formation of saucer-like objects zipping over Mount Rainier in 1947, these sightings have remained largely subjective. Many are documented, but few are substantiated beyond a reasonable doubt. After nearly fifty years, all we have are hundreds of thousands of anecdotes, indistinct photos, and both over- and underexposed videos. No downed saucers; no alien corpses; no hard data. Belief in the alien nature of UFOs ultimately requires, like a belief in God, a leap of faith.

This dearth of evidence has often prompted astronomers to suggest that the whole UFO/alien question be deferred to experts in the behavioral sciences. As we see in C. D. B. Bryan's recent effort, *Close Encounters of the Fourth Kind: Alien Abduction, UFOs, and the Conference at M.I.T.*, this is exactly where the locus of UFO studies appears to be centered these days.

Bryan, a novelist and respected journalist, covered a five-day scientific conference held at MIT in 1992 devoted to the subject of alien abductions. In attendance were numerous psychologists, physicians, physicists, hypnotherapists, folklorists, and even a few astronomers. A great many of the audience, however, consisted of abductees, those who claimed to have had a close encounter of the fourth kind, in which physical contact between an individual is initiated by occupants of alien spacecraft.

If you are a dyed-in-the-wool UFO skeptic, it is jarring to realize that a prestigious university would even allow such a conference to be held on their campus. And yet, according to Bryan, the true spirit of seeking scientific truth was apparent and in force.

The cement binding this conference to a cause worthy of study is the undeniable fact that, whether you believe them or not, reports of alien abductions are on the increase. In the U.S. alone, Bryan's experts estimate that 900,000 people believe they have been abducted by aliens.

The skeptic's first visceral reaction is, "Preposterous!" But look again. There are some intriguing psychological aspects to these reports. For one thing, as Bryan shows, although the details of the accounts vary, there are many singular commonalties reported by people who do not appear to be seeking their 15 minutes of fame, who do not know each other, and who come from a wide variety of backgrounds in terms of education, social class, and media exposure (which often gets blamed for these abduction stories). Bryan thoroughly reports on these accounts and notes their similarities. In addition, he interviews abductees and researchers, attends

[continued on page 96]

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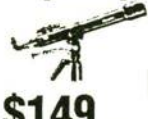

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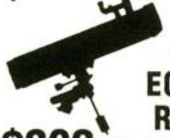

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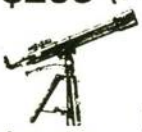

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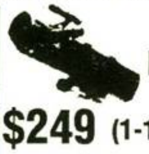

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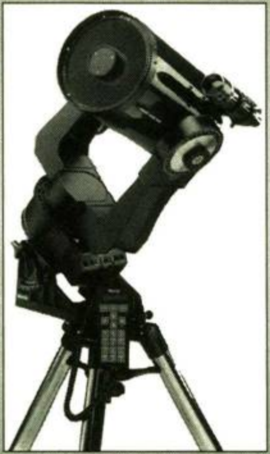

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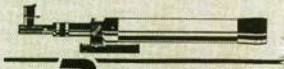

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hypnotherapy sessions, and paws through archives of past UFO reports. He is seeing this phenomenon for the first time, and in so doing brings a refreshing objectivity to a literature riddled with madmen, fools, and charlatans. Hopefully, Bryan's diagram of this phenomenon will be the first of its kind.

When I first picked up *Close Encounters*, I was expecting the usual roster of bizarre stories told by ostracized and (forgive the pun) alienated individuals vying for attention. But as I continued reading one comparable account after another, I began experiencing a low-grade disquiet. I found myself asking, "What's going on here?" What is Bryan trying to get me to see? About one quarter of the way into it, I realized the author's intent was not to convince me that an increasing number of people are being abducted by aliens, but to get me questioning why so many people *believe* that they are.

The reason has nothing to do with seeking fame or attention, which is how many skeptics may explain these behaviors. But in the vast majority of cases, abductees do everything they can to avoid the public eye. Only when the symptoms of their suppressed abduction intrude on their lives do they seek help from a scientist or hypnotherapist. Even at the MIT conference, where they could have basked in the "glory" of their experience, their name tags were inscribed with only their first name.

Although Bryan's book does not offer a hard-and-fast explanation for the experiences of abductees, several theories are suggested. Not surprisingly, some researchers consider the abduction episodes to be spawned by a combination of social and psychological causes. But which causes and why? No one seems to know.

Other researchers unabashedly declare that the abductees are only reporting what they experience, that indeed they are being abducted by alien beings. The purpose? Again, no one really knows. Usually some sort of grand mutually beneficial genetics experiment is cited, one designed to save us, and "them" from some sort of unknown destruction. Assuming for the moment this scenario is true, what is the basis for the selection criteria? Why these people? And why do they suffer so?

Much is left open ended in Bryan's book, but that is to be expected when

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you're dealing with a phenomenon resulting from unaccountable causes. One might complain that Bryan was not the journalist best suited to cover this subject, that his background in UFO research, behavioral science, and astronomy is not comprehensive enough. I would counter, however, that in this case the author's curiosity, open mindedness, and naïveté work to lend a legitimacy to a subject that is perhaps considered illegitimate for all the wrong reasons. For no matter how skeptical you are, you cannot get away from the numbers: millions of people worldwide believe they have been contacted by aliens. What is the social psychological significance of such a claim?

Bryan's experts speculate that we may be witnessing the emergence of a new psychological disorder, or a heretofore unknown social dynamic. This, I believe, must be the force at work behind the alien abduction phenomenon. After all, society-wide psychological ailments such as seasonal affective disorder and chronic fatigue syndrome were not completely diagnosed until recently by psychotherapists. Perhaps "alien abduction disorder" falls into the same category.

But how would such a disorder evolve? It is in the nature of human beings to look for meaning and purpose in life: a satisfying career, true love, God. Are some people so removed from their own personal disillusionment and social disaffection that they hallucinate help coming from the skies in the form of alien saviors — saviors, I might add, that oftentimes behave sinisterly?

In any case it would be a mistake to consider *Close Encounters of the Fourth Kind* a ramrod treatise in support of UFO abductions, government conspiracies, and the like. It is definitely not. Bryan admits throughout the book that he can't bring himself to believe all that he has heard, and never does he advocate that aliens are truly behind this phenomenon. *Close Encounters* is the voice of millions of tormented individuals who for some inexplicable reason share the alien abduction experience. This is not so much a book about encounters with a race of extraterrestrials as it is about encounters with some unknown aspect of ourselves. It describes, in the words of the French UFO scientist in Steven Spielberg's movie *Close Encounters of the Third Kind* what is truly an "event sociological." — *Jeff Kanipe*

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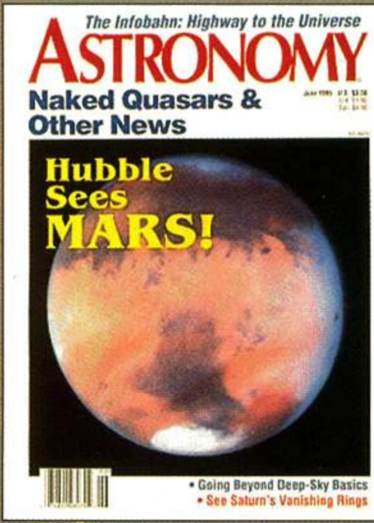
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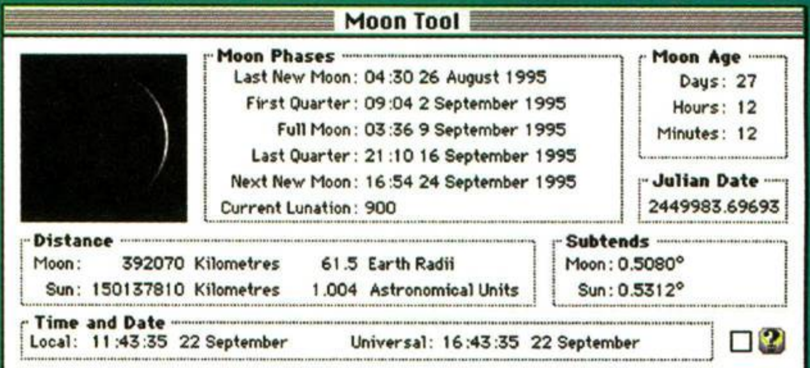

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Moon Phases
Last New Moon: 04:30 26 August 1995
First Quarter: 09:04 2 September 1995
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Current Lunation: 900

Moon Age
Days: 27
Hours: 12
Minutes: 12

Julian Date
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Distance
Moon: 392070 Kilometres 61.5 Earth Radii
Sun: 150137810 Kilometres 1.004 Astronomical Units

Subtends
Moon: 0.5080°
Sun: 0.5312°

Time and Date
Local: 11:43:35 22 September Universal: 16:43:35 22 September

Sometimes the best things in life are free. I'm talking about freeware, the myriad of free programs available through the Internet. Access to these programs is even easier nowadays through the World Wide Web. Web browsers such as *Mosaic* or *Netscape* make the transfer — and, often, the decompression or translation — of programs a matter of just a few mouse clicks. The user doesn't have to know anything about ftp, .hqx, BinHex, and other computer exotica.

Many software repositories exist. Common ones are the SUMEX site at Stanford University (type in ftp://sumex.stanford.edu for the location), WUARCHIVE at Washington University (ftp://wuarchive.wustl.edu), MERIT at the University of Michigan (ftp://ftp.merit.edu), Microlib at the University of Texas at Austin (ftp://microlib.cc.utexas.edu), and the mirror site at the University of Michigan (ftp://mirror.archive.umich.edu). Web browsers can visit all these sites simply by opening http://nw.com/bahnware/gateways/selected-ftp-sites.html.

Check out the software at Jumbo (http://www.jumbo.com/index.html) and the University of Texas Mac archive (http://www.ots.utexas.edu/mac/main.html). Jumbo has software for DOS, Mac, and Windows programs. The Mac archive has some astronomy software I haven't seen elsewhere. UT's Mac archive gives program-seekers lots of power because it's listed in four different ways: according to title, type of program, author, and date of release.

To support my contention that valuable freeware programs exist, try out *Moontool* for the Mac (version 1.0.1). It graphically shows the present phase of the Moon and lists the dates and times of major phases, the age of the Moon, the current distance to the Sun and Moon, the sizes of the Sun and Moon, and the present Julian date and Universal time. Users can shrink the window to an icon on the Mac desktop to constantly display the lunar phase.

The times, sizes, and distances all appear to be accurate when compared with the *Astronomical Almanac*, although the lunation number (number of New Moons since the one in January 1923, continuing the series started by E. W. Brown) appears to be off by one, referring to the next New Moon not the last one. Thanks go to Richard Knuckey of New Zealand for writing and sharing this program.

When browsing these archives, don't mistake shareware for freeware. Freeware is absolutely free; the developer had fun writing the program and wants to share it with everyone. Shareware looks free, but users have a moral obligation to pay the nominal registration fee after the free trial period.

— Dave Bruning

Lumiview 1.0

Waldee-Wood Astronomical Software, distributed by Allegro Music: Software Division, 1468 Kimberly Drive, San Jose, CA 95118, (408) 723-3655. Price: $23.95. Minimum requirements: IBM PC-compatible computer and DOS; a VGA display is required to display graphics.

Deep-sky observers can use *Lumiview* to determine which objects will be visible given a combination of telescope, eyepiece, and limiting sky magnitude. After entering telescope characteristics such as diameter and focal length or ratio, users can either choose an appropriate eyepiece from an extensive list or enter the specifications directly. The program then computes the exit pupil, apparent field, and theoretical resolution. Or the user can specify the exit pupil, magnification, or field of view desired and the program will select an appropriate eyepiece. The database can store 10 files of frequently used scope-eyepiece combinations.

To vividly demonstrate the effects of the various nebular and light-pollution-rejection filters, Lumiview shows before-and-after views of assorted objects, such as the Orion Nebula, the Horsehead Nebula, the Veil Nebula, and the Andromeda Galaxy. Although these views don't directly reproduce the view seen through the scope-eyepiece-filter combination selected by the user, they do mimic what one sees visually through telescopes.

The software incorporates the basic parts of Waldee-Wood's *Redscope* program and eyepiece database to accurately calculate the magnification and field of view seen with various eyepiece and telescope combinations. Additional features include exposure time calculations for individual objects and an on-line guide to astronomy. The exposure times are for hypered films; users of nonhypered films are given conversion factors. The on-line guide includes a manual for using the program, deep-sky object descriptions, glossaries of terms, sections on Lumicon filters, instructions on using a telescope, and an overview of astrophotography.

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Access to the journal is free until 1997. Back issues starting in July 1995 are also available. Readers can view either an HTML file using a Web browser or a PDF file using *Adobe Acrobat*. Figures are embedded in the article in both formats, and users may search the text for terms or researchers' names.

Watch the Weather

Weather presents the greatest obstacle to astronomers, so accurate forecasts are important to planning successful observing sessions, especially ones that require transporting a scope to a distant site. The Weather Channel provides great radar maps and up-to-date forecasts all day on cable TV. But what do astronomers not connected do to catch the latest weather imagery? Some pull weather maps out of thin air using a weather fax.

Any shortwave radio capable of tuning into single-side-band transmissions can receive facsimile broadcasts of satellite imagery and National Weather Service forecasts. A computer with a simple patch cord can interpret these signals and display the image.

One company selling the radio-to-computer interface cable is DATA*LNK (Howard Olsen, 5411 Atlantic View, St. Augustine, FL 32084). For $49, DATA*LNK provides an interface that connects to either a 9-pin or 25-pin serial port (specify which), instructions, and a reference guide to freeware and shareware programs that will display the images. A kit for building an interface is also available for $24.

A more sophisticated system enables users to grab the image directly from a weather satellite. MultiFAX (Route 1, Box 27, Peachland, NC 28133, (704) 272-9028, fax (704) 272-9036) sells signal demodulators for connecting a radio to a computer. Certain satellites require specific types of antennas to receive the signals. The *MFMAP7* software will display weather images, track low-orbit satellites, automatically download images when a satellite is overhead, superpose a world map on images, and convert an image into GIF format for use in other programs. □

Software developers may send new programs and upgrades to AstroBytes, Astronomy Magazine, P.O. Box 1612, Waukesha, WI 53187-1612 or e-mail bytes@astronomy.com. Check out ASTRONOMY*'s home page at* **http://www.kalmbach.com/astro/astronomy.html.**

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RESOURCES & PHOTOFACTS

Galileo Arrives at Jupiter (page 36)

The Giant Planet Jupiter, by John H. Rogers (Cambridge University Press, 1995). This massive book by the director of the Jupiter section of the British Astronomical Association contains a complete summary of everything that was known about Jupiter and its satellites prior to Galileo's arrival.

Second-Chance Planets (page 50)

"Lost & Found: Pulsar Planets," by David Bruning, ASTRONOMY, June 1992. Contains a discussion of the pulsar planets that exist, and the ones that turned out not to exist.

"Forbidden Planets," by Tim Folger, *Discover*, April 1992. Another article that explains possible ways planets could form around a pulsar.

"Pulsing Stars Confirm More Planets in the Universe," by John Travis, *Science*, April 22, 1994. A clear and thorough explanation of how Alex Wolszczan discovered and confirmed the pulsar planets. Wolszczan's paper that clinched the existence of pulsar planets appears in this same issue.

A Trip Through the Wasteland (page 68)

Burnham's Celestial Handbook, by Robert Burnham, Jr. (Dover, 1978). A massive, three-volume tome that includes the objects Camelopardalis and Lynx.

Touring Winter's Best Double Stars (page 72)

Celestial Objects for Common Telescopes, by T. W. Webb, (Dover Publications, 1962). A timeless, two-volume observer's guide that presents hundreds of double star descriptions.

Webb Society Deep-sky Observer's Handbook, Vol. 1, edited by Kenneth Glyn Jones, (Enslow Publishers, 1986). Cites the nature of double stars, how to observe them, a history of their observation, and a complete catalogue of many targets.

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p. 48: Martin C. Germano; **p. 68:** Kim Zussman, modified 11-inch SCT at f/10, hypersensitized Tech Pan film, 70-minute exposure; **p. 69, top:** George Greaney and Mike Newton, 14-inch SCT at f/7, Fuji Super HG 400 film, composite of two 50-minute exposures; **bottom right:** Preston Scott Justis, 10-inch f/6 reflector, hypersensitized Tech Pan film, 60-minute exposure; **bottom left:** Lee T. Macdonald, 8.5-inch reflector at 130x; **p. 70, top:** Preston Scott Justis, 10-inch f/6 reflector, 103a-O film, 70-minute exposure, **center:** Preston Scott Justis, 10-inch f/6 reflector, hypersensitized Tech Pan film, 90-minute exposure; **bottom:** Lee T. Macdonald, 8.5-inch reflector at 130x; **p. 71, top left:** Martin C. Germano, 8-inch f/5 reflector, hypersensitized Tech Pan film, 75-minute exposure; **top right:** Martin C. Germano, 8-inch f/5 reflector, hypersensitized Tech Pan film, 65-minute exposure; **bottom:** Martin C. Germano, 8-inch f/5 reflector, hypersensitized Tech Pan film, 90-minute exposure; **p. 78:** James L. Matteson, 5 1/2-inch f/1.65 Schmidt camera, Fuji F100 film, 2½-minute exposure taken in 1976; **p. 79:** Jeff Schroeder, 50mm lens at f/2.8, Ektachrome 400 film, 2-minute exposure taken April 8, 1986; **p. 80, top:** Chris Schur, 8-inch f/1.5 Schmidt camera, hypersensitized Tech Pan film, 10-minute exposure with a yellow filter, taken December 20, 1987; **bottom:** James Cornell, Smithsonian Astrophysical Observatory, taken in October 1965; **p. 81:** Dennis Sørenson, 10-inch f/6 reflector, T-Max 400 film, 10-minute exposure taken August 18, 1990; **p. 82, top:** Michael Stecker, 8-inch f/4 reflector, hypersensitized Tech Pan film, 10-minute exposure taken September 6, 1989; **bottom:** Michael Stecker, 8-inch f/4 reflector, hypersensitized Fujichrome 100, taken August 26, 1990; **p. 83:** Robert Provin, taken in 1976; **p. 111, top:** Franz Kersche, 6-inch f/7 refractor, hypersensitized Tech Pan film, 120-minute exposure; **bottom left:** Ken Blankenship and Dennis Batis, 14-inch f/11 SCT, hypersensitized Kodak Royal 400 film, 270-minute exposure with a Lumicon skyfilter; **bottom right:** Martin C. Germano, 14.5-inch f/5 reflector, hypersensitized Tech Pan film, 65-minute exposure; **p. 112, top:** Franz Kersche, 6-inch f/7 refractor, hypersensitized Tech Pan film, 120-minute exposure; **middle:** Greg Terrence, 16-inch reflector at f/20, Lynxx PC CCD camera, composite of twenty 20-second exposures; **bottom:** Kim Zussman, 14.5-inch f/8 Cassegrain, hypersensitized Tech Pan film, 189-minute exposure; **p. 113:** Luke Dodd, 55mm lens, hypersensitized Fuji 400 film, composite of two 25-minute exposures; **p. 114:** Giovanni Quarra, 5-inch f/8 refractor, Compuscope CCD800 CCD camera, composite of three ¼-second exposures on April 8, 1995. □

MEETINGS & EVENTS

January 27-February 2
Photonics West '96 Symposium, San Jose, California. Contact SPIE, P.O. Box 10, Bellingham, WA 98227-0010, (360) 676-3290, spie@spie.org.

February 8-13
AAAS Annual Meeting, Baltimore, Maryland. Contact the AAAS Meeting Office, 1333 H Street, N.W., Washington, DC 20005, (202) 326-6450, or amsie96@aaas.org.

February 12-18
Winter Star Party, near Key West, Florida. Sponsored by the Southern Cross Astronomical Society. Contact Bob or Sharon Grant, 5401 SW 110 Avenue, Miami, FL 33165, (305) 595-8778.

February 15-18
The Orange Blossom Special, near Brooksville, Florida. Contact Dennis Farr, 8811 West Broad Street, Tampa, FL 33615, (813) 884-9111.

February 24
Wagman Winterfest, near Russellton, Pennsylvania. Contact the AAAP at Wagman Observatory, (412) 224-2510.

February 25-29
Smart Structures and Materials Symposium, San Diego, California. Contact SPIE, P.O. Box 10, Bellingham, WA 98227-0010, (360) 676-3290, spie@spie.org.

March 17-20
Visual Communications and Image Processing, Orlando, Florida. Contact SPIE, P.O. Box 10, Bellingham, WA 98227-0010, (360) 676-3290, spie@spie.org.

March 18-22
Lunar and Planetary Science Conference, Houston, Texas. Contact LeBecca Simons, LPI Publications and Programs Services Department, 3600 Bay Area Boulevard, Houston, TX 77058-1113, (713) 486-2158.

June 14-16
Jersey Star Quest VI, Sussex, New Jersey. Contact Greg Mauro, Jersey Star Quest VI, 4 Crosswicks Court, Trenton, NJ 08610, (609) 585-9465. □

Please submit notices four months in advance to Meetings and Events, ASTRONOMY, P.O. Box 1612, Waukesha, WI 53187, or tstaedter@astronomy.com.

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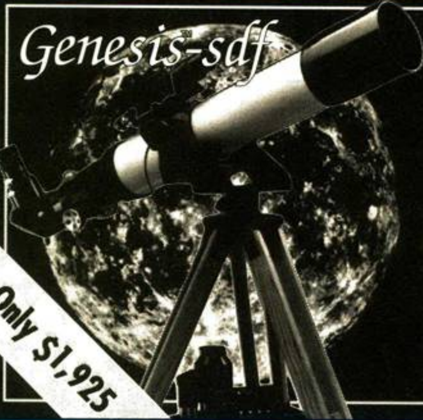

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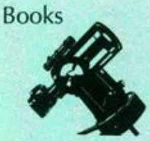

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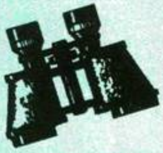

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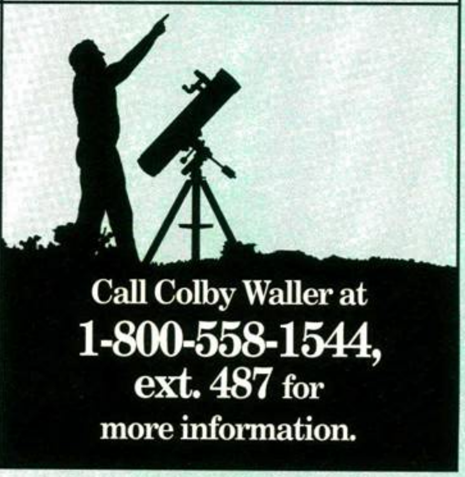

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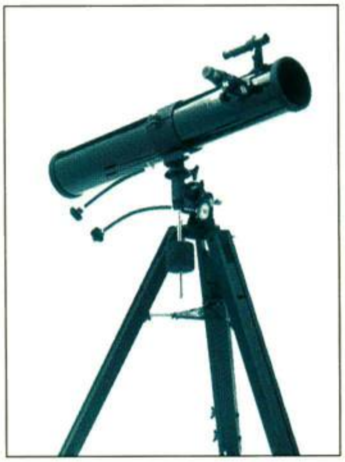

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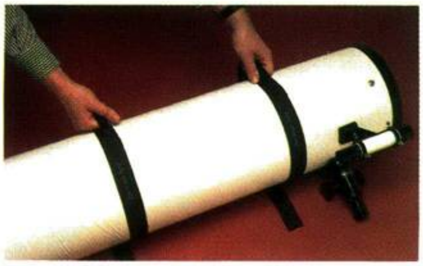

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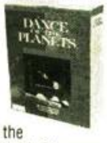

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Michael Stecker

GET READY FOR HALE-BOPP Perhaps the brightest comet in 20 years, Hale-Bopp should put on a spectacular display during the next 15 months.

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You can create stunning nightscapes by compositing or sandwiching your photos, and it's not as hard as you might think.

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The Solar System Parade

An increasingly busy summer and autumn 1995 produced an unusual number of bright comets visible in binoculars and even to the naked-eye.

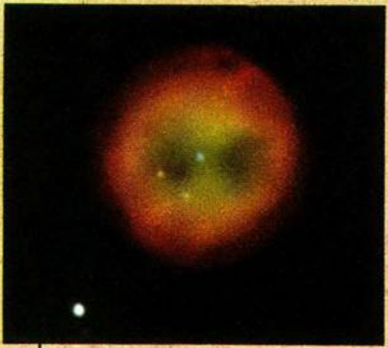
- **Comet Hale-Bopp** (C/1995 O1) brightened during August and September, reaching magnitude 10.3 by October 1. The comet continued its slow movement through Sagittarius. Hale-Bopp will sprout a noticeable tail and grow in brightness after it returns to visibility in February 1996. The comet should reach naked-eye brightness by August.
- **Comet De Vico** (P/1995 S1) was recovered on September 18, 1995, by Japanese amateur astronomers Yuji Nakamura, Masaaki Tanaka, and Shougo Utsunomiya. The comet shone at 7th magnitude at discovery and displayed a 5' coma and a 25'-long tail. Orbital calculations showed the comet appeared in 1846 and should have again in 1922 but apparently was missed.

De Vico moved through Hydra and into Leo during early October, brightening to magnitude 5.7 on October 14. Nearby, Comet Bradfield (C/1995 Q1) faded through September and October from magnitude 7.1 to 10. On October 10 De Vico and Bradfield were separated by only 5° in northern Leo, glowing at magnitudes 5.6 and 8.9.

- **Activity on Jupiter**. Jose Olivarez of Wichita, Kansas, reports observations of Jupiter from June 13–15, 1995. "The colors are striking in my 16-inch scope. The North Equatorial Belt is

The Andromeda Galaxy

by Franz Kersche
(6-inch f/7 refractor, hypersensitized Tech Pan film, 120-minute exposure)



The Owl Nebula in Ursa Major

by Ken Blankenship and Dennis Batis
(14-inch f/11 SCT, hypersensitized Kodak Royal 400 film, 270-minute exposure with a Lumicon skyfilter)

The UGC 10638 Galaxy Chain

by Martin C. Germano
(14.5-inch f/5 reflector, hypersensitized Tech Pan film, 65-minute exposure)

mainly orange in color and its southern edge has a bluish fringe. The Great Red Spot appears as a light orange color and appeared more like a streak than an ellipse."

- **Martian Features Observed**. Dan Troiani of Schaumburg, Illinois, Mars Recorder for the Association of Lunar and Planetary Observers, reports extensive activity on Mars during the 1995 season. Observations came from a number of Mars watchers and included comments: "Chryse appeared whitish," Walter Haas, April 7, 1995; "the north polar cap looked irregular with a small evening cloud on its western edge," Don Parker, May 12; and "Bright evening clouds and a possible rift in the north polar cap," Parker, June 11.

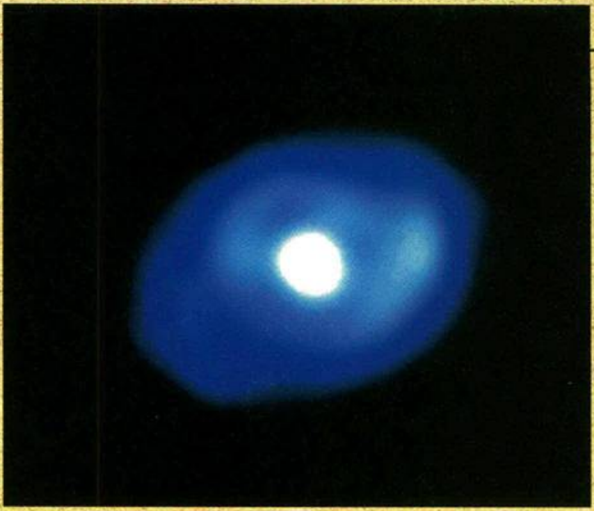
- **Comet Honda-Mrkos-Pajdusakova**. Another relatively bright comet will be visible this month: Comet HMP, a comet discovered in 1948. Richard R. Didick of Rehoboth, Massachusetts, alerts readers to this enjoyable binocular object.

"This periodic comet has a period of 5.27 years, " says Didick, "and it is one of the faintest known comets, becoming active when it's just over 1 AU from the Sun." During this passage the comet will be visible low in the evening sky in the constellations Sagittarius and Capricornus. The comet should peak in brightness at magnitude 6.9 on December 29, 1995. For a table of positions and magnitudes, see Sky Almanac. Reader observations of each of these bright comets are welcome.□

ASTRONOMY wants to hear about your observations of the sky. Send reports, sketches, photographs, and disks to David J. Eicher, Reader Reports Editor, ASTRONOMY, P.O. Box 1612, Waukesha, WI 53187. Please label each photo with name, address, and social security number. You may send written reports via the Internet to: rreports@astronomy.com

The Veil Nebula in Cygnus

by Franz Kersche (6-inch f/7 refractor, hypersensitized Tech Pan film, 120-minute exposure)

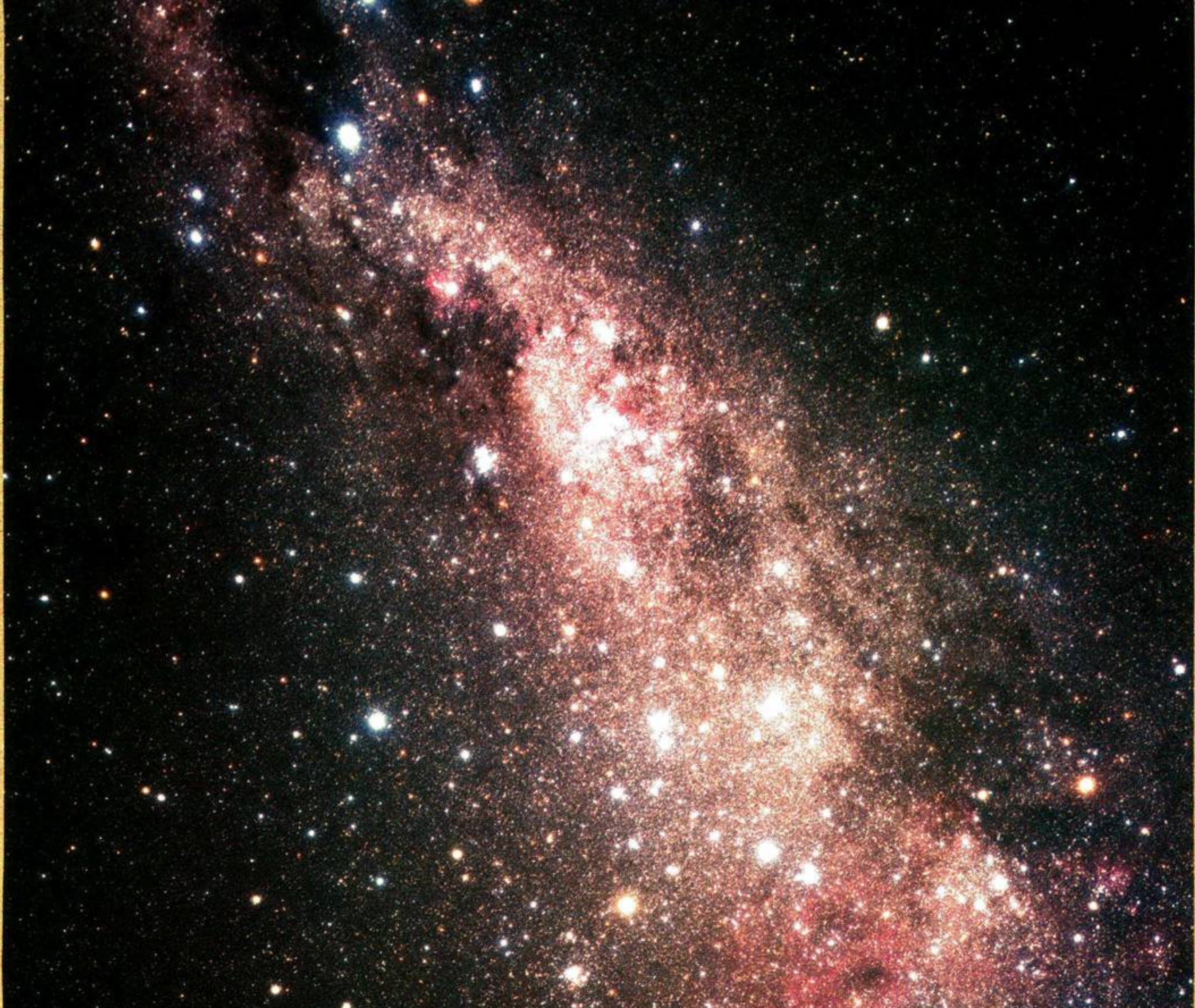


Planetary Nebula NGC 6543

by Greg Terrence (16-inch reflector at f/20, Lynxx PC CCD camera, composite of twenty 20-second exposures)

Irregular Galaxy IC 2574

by Kim Zussman (14.5-inch f/8 Cassegrain, hypersensitized Tech Pan film, 189-minute exposure)



Carina, Vela, and Puppis

by Luke Dodd
(55mm lens, hypersensitized Fuji 400 film, composite of two 25-minute exposures)

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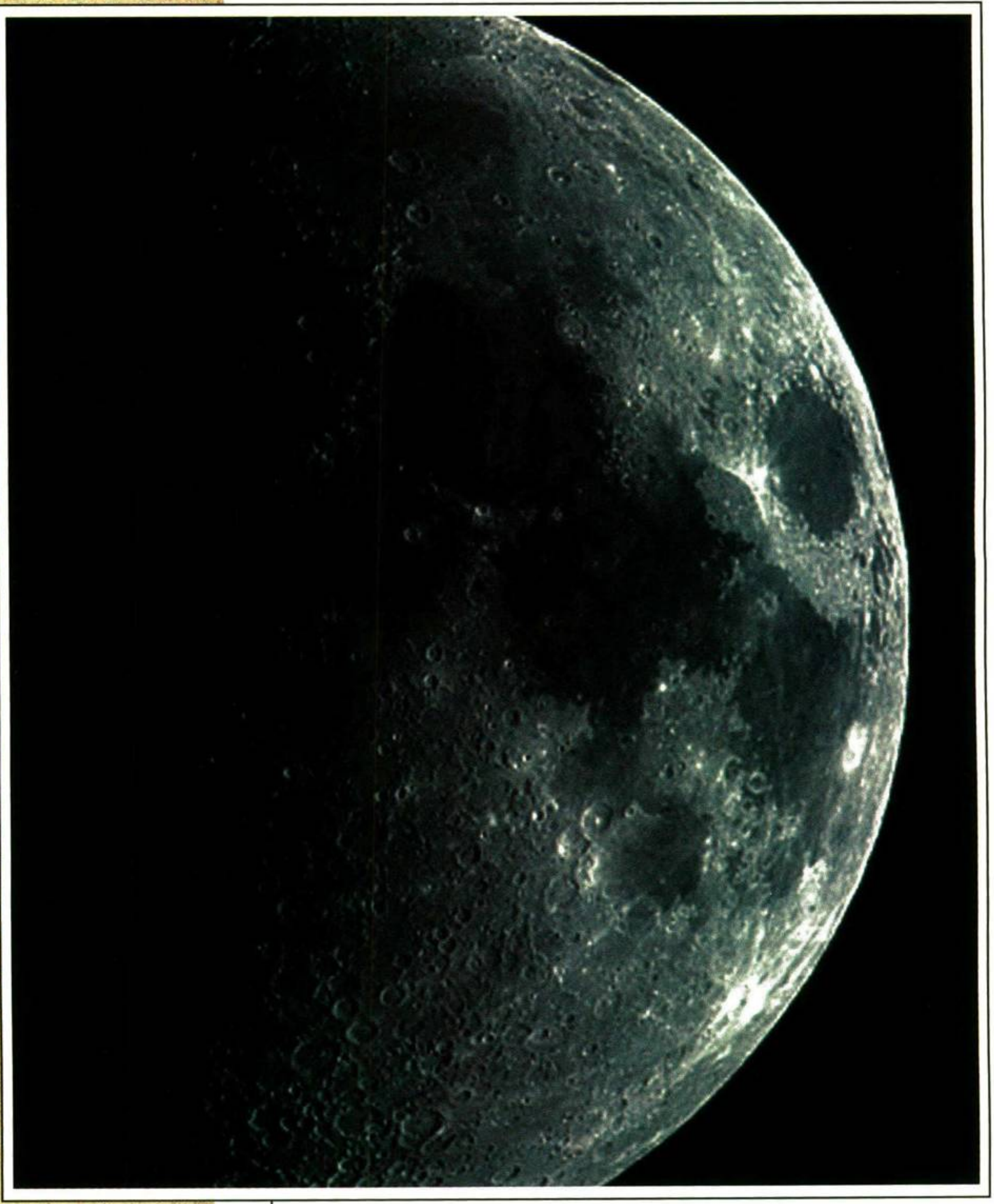

The Moon at First Quarter

by Giovanni Quarra
(5-inch f/8 refractor, Compuscope CCD800 CCD camera, composite of three ¼-second exposures on April 8, 1995)

The seeing was "average" for this series of lunar exposures shot from the San Gersolä Planetary Observatory in Florence, Italy. "My group began imaging planets in 1990," says Quarra, "and we are very active within the Italian Amateur Astronomers Association and keep in touch with British and American planetary groups like the BAA and ALPO."

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(Required by 39 U.S.C. 3685)

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Kettering and District Amateur Astronomers Society meets at 7:30 pm on the first and third Tuesday of each month at the Quaker Meeting Hall, Northall Street, Kettering, England. Correspondence invited from other societies. Contact Steve Williams, 120 Brickhill Road, Wellingborough, Northants, NN8 3JP, England.

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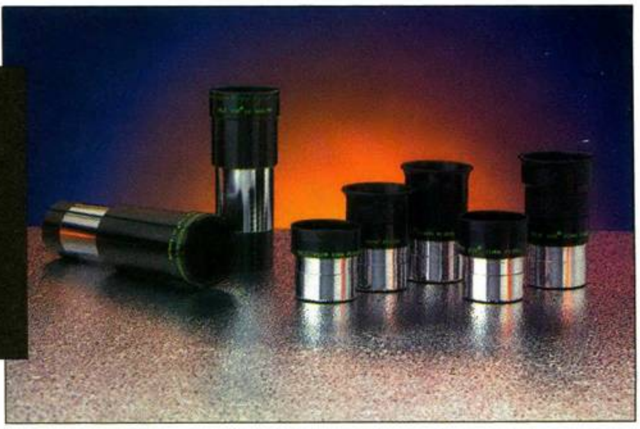

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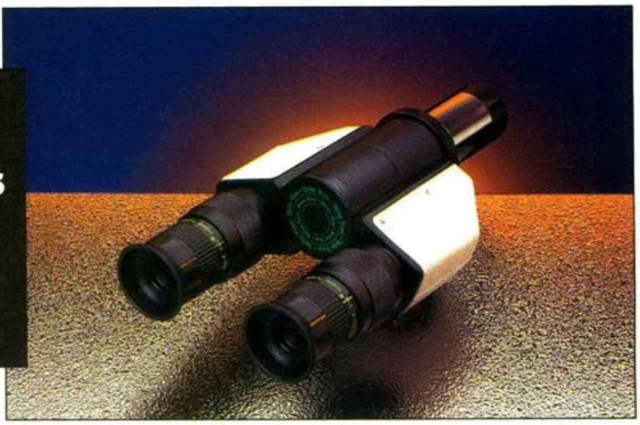

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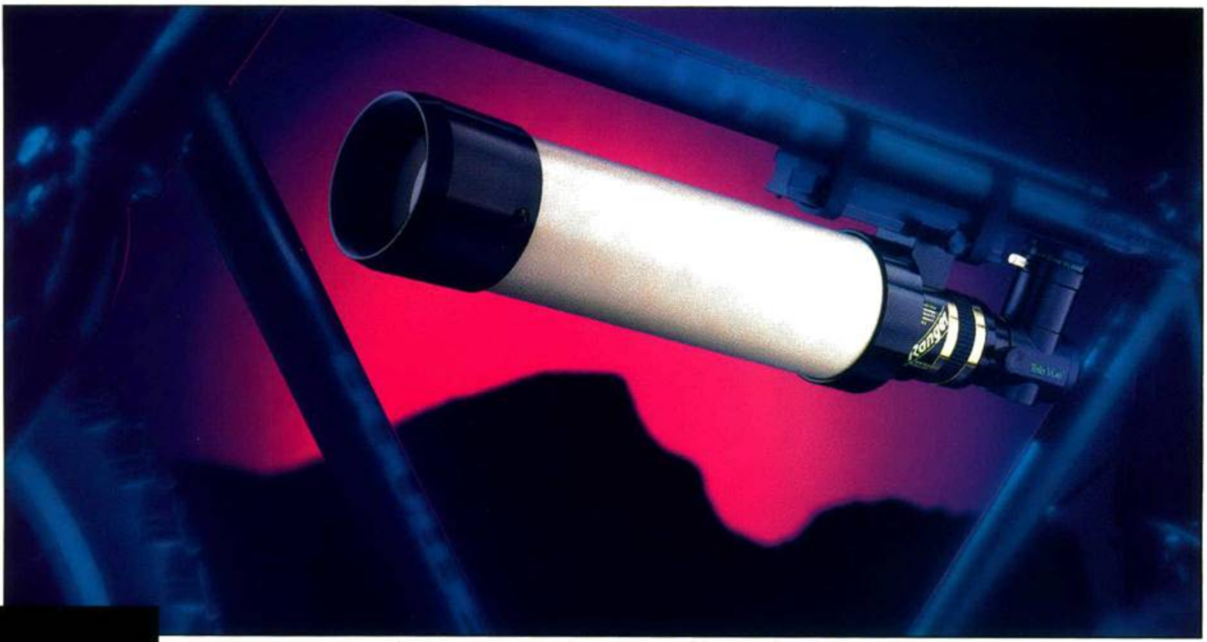

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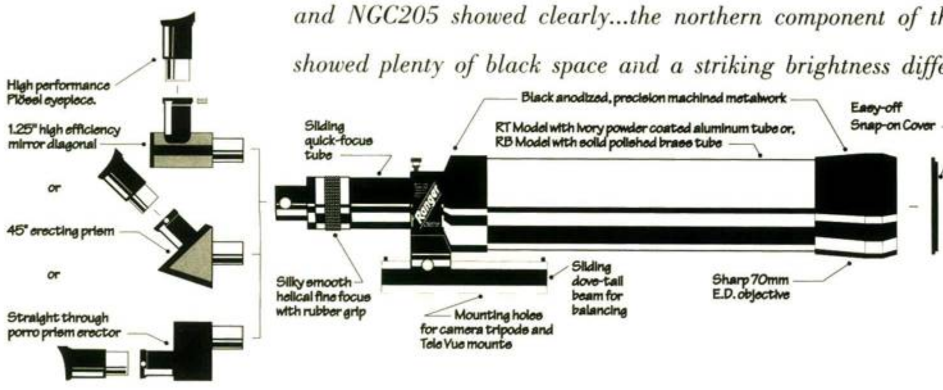
FEATURES: Rugged construction, 3.5 lbs., 480mm f.l. E.D. obj., 12x to 200+ power, Plössl eyepiece

"We put Tele Vue's new 70mm f/6.8 refractor through its paces and discovered an ideal travel telescope for astronomy, wildlife, or sports...From the practical observer's viewpoint, it is nice to know there is finally a true multipurpose small telescope available." — Sky & Telescope, Nov. '95. Ranger combines light weight with rugged construction, attractive cost with fine American craftsmanship, and rich field/deep sky views with diffraction limited, planetary performance — all to satisfy owners of any experience level. Active users agree. "My new Ranger is great! The wide field, pinpoint star images and portability make it a joy to use — both at night and during the day. I used to have an 8" Dob, but I enjoy the Ranger more." — Tom Gregory, CA Enjoyable viewing is Ranger's forte.

S&T's editor Barlow Pepin observed "a distinct granularity to its (M15) core...Saturn's moon Titan as a pinpoint and a clear edged planetary disc of pale beige yellow with hazy equatorial banding...even in strong moonlight, the tiny, elaborate trapezium of M29 stood out clearly...the companions of Andromeda, M32 and NGC205 showed clearly...the northern component of the Double-Double showed plenty of black space and a striking brightness difference between its components. — this with a scope I picked up with one hand and carried across the yard!"


High performance Plössl eyepiece.
1.25" high efficiency mirror diagonal
or
45° erecting prism
or
Straight through porro prism erector
Sliding quick-focus tube
Silky smooth helical fine focus with rubber grip
Black anodized, precision machined metalwork
RT Model with ivory powder coated aluminum tube or, RB Model with solid polished brass tube
Mounting holes for camera tripods and Tele Vue mounts
Sliding dove-tail beam for balancing
Sharp 70mm E.D. objective
Easy-off Snap-on Cover
Ranger

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CIRCLE NO. 24 ON THE READER SERVICE CARD

NEW PRODUCTS

Ultima® 9¼

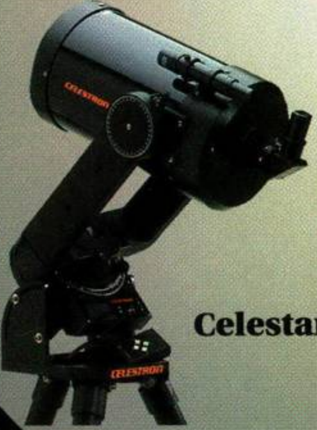
The **Ultima® 9¼** introduces a new and unique aperture to the astronomical community. The mount is a rugged sand cast aluminum design. The wedge and tripod are both newly designed for added rigidity and stability. The electronics are the same as used in the highly successful Ultima 8 — and run with a 9 volt battery for totally cordless operation. The DC Servo Quartz drive system combined with a super precision gear set gives unprecedented drive accuracy.

CG-9¼

The **CG-9¼** is a large 9¼" aperture, 2350mm f/10 telescope. It comes with a superb German equatorial mount built for Celestron by Losmandy. The electronics are the same as supplied with the CG-11 and feature PEC, TVC, multiple speeds, etc. The tripod is a Celestron new design and is lightweight but very rugged and added stability (if needed) is obtained by using the optional accessory tray. A unique focusing micrometer is standard.

CELESTRON®

The **Celestar 8** was designed for the budget conscious but without sacrificing quality and still providing many useful features. The new and unique Wedgpod is of a fixed height design — lightweight but very stable. The drive is DC operated by a single 9 volt alkaline battery. The 8", f/10 optics feature the high transmission Starbright® coatings. Another new model is the **Celestar 8 Computerized** which includes the Advanced Astro Master®.



Celestar 8

Ultima® 11

The **Ultima® 11** is being reintroduced due to popular demand from those who want a large aperture but prefer a fork mount. So, we redesigned the fork mount using strong aluminum sand castings and then redesigned the tripod and wedge for added stability. The electronics and gear system are the same as supplied with the **Ultima® 9¼**. The highly touted optics are the same high quality as you would expect from Celestron.

CELESTRON has the well-deserved reputation of providing affordable optical excellence. This reputation was gained through our 30 plus years of experience and success in product design, development and continual product improvement.

Continuing with this tradition, the new products announced above were developed considering the substantial input from you — the consumer. These **new products** address different requirements for people with various interests and budget considerations.

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